Harald Plachter
Ulrich Hampicke
(Eds.)

Large-scale Livestock Grazing

A Management Tool for Nature Conservation

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Translated from German by Les Reay

With 195 Figures and 122 Tables

Springer

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We dedicate this book to
Manuel Conradi †
who inspired us by his commitment
and his skills to solve problems by new ideas

Preface

In our societies livestock grazing has a disgusted smell. It was the reason for the soil loss in the Mediterraneans, it was the reason for the degradation of forests in Central Europe in historic times, and it is the driving force for the clearcutting of primeveal forests in developing and underdeveloped countries. Pictures of over-grazed land in arid zones come into our minds, the soils unprotectedly exposed to the eroding powers of wind and water.

In Europe livestock, like no other human activity, coined cultures and landscapes over more than 5 000 years. Like in other continents it was not always a kind of use which we would call "sustainable" in modern interpretation. However, it generated diversity on the landscape level and supported the development of ecosystems and species which we today like to protect. Most of the nutrient-poor grassland and shrub ecosystems owe their existence to the grazing of livestock or the necessity to feed them. Thermophilous plant and animal species found new habitats on grazing land, including forests.

This book summarizes the results of scientific investigations on the influence of large-scale pasturing on nature, conducted in Germany, Sweden, Ukraine and Georgia. The basic thought is: if livestock pasturing has contributed to generate the values of the kind of nature and landscapes which we today strive to protect, why not use it as a management tool? Of course, some modern forms of livestock keeping are obviously unsuitable to meet conservation targets. Today livestock is often kept in stables and if not is allowed to graze on small fenced paddocks only, which are normally fertilized, hosting only a poor level of biodiversity.

But merging modern and historical techniques might result into a strategy well suited for landscape management. The validity of such models depends on the costs, for the farmer and for society, compared to other alternatives. Only if economical analyses back up such perspectives they will be realized on ground.

The scientific and technical findings of this book are the result of the co-operation of many people. Editors and authors especially like to thank: Karl-Friedrich Abe, Kaltensundheim; Aribert Bach, Kaltensundheim; Matthias Dehling, Marburg; Sandro Didebulidze, Tbilisi; Angelika Fuß, Marburg; Helena Lager, Kalmar; Giorgi Nakhutsrishvili, Tbilisi; Ewald Sauer, Gersfeld; Beate Schütze, Berlin; Valentyn Stetsiuk, Lviv; Karl Stumpf, Ehrenberg; Josif Tsaryk, Lviv; Tengiz Urushadze, Tbilisi.

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Harald Plachter, Marburg — Ulrich Hampicke, Greifswald

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Chapter 1

Livestock Grazing and Nature Conservation Objectives in Europe

Ulrich Hampicke · Harald Plachter

1.1
Introduction

The Agenda 21, which was adopted at the 1992 Earth Summit in Rio de Janeiro, resulted in the general concept of 'sustainable development' as a political guideline around the world (UNCED 1992). The protection of nature, its ecological functions and natural resources has a central role in this context, not least because of the regulations of the Convention on Biological Diversity (CBD) (Goodland et al. 1992; Haber 1998a,b; IUCN 1980; McNeely et al. 1990). However, it has become increasingly clear that even in a globalized world, these objectives can only be achieved if every region and country identifies its specific priorities and pursues them with an appropriate strategy. In hardly any other area of society has the principle 'think global, act local' such relevance as in nature conservation.

Europe's contribution to a world-wide conservation strategy must take into account the particular development and current situation concerning the subject of protection. There is a complete lack of untouched nature in Europe, perhaps with the exception of a few narrowly restricted areas. The European landscapes are characterized predominantly by agricultural activity featuring both crop and livestock production and even the woodlands were and still are generally exploited (forestry, various agricultural uses, hunting etc.). These rural cultural landscapes are, in contrast to other regions of the world, home to the largest proportions of the present-day species and varieties of ecosystems in Europe (Stanners and Bourdeau 1995). A 'co-evolution' between humans and nature over 5 000 years has created the basis of a high level of biodiversity, even in farmed landscapes (Phillips 1996; Plachter 1995, 2004; Plachter and Roessler 1995). The condition and development of this is therefore a central criterion for the success or failure of nature conservation on this continent (Phillips 1998; Plachter 1996a, 1999a,b; Plachter and Puhlmann 2004). Consequently, there are general approaches which lie at the center of European nature conservation for the attainment of a future sustainable development of the cultural landscapes (Deutscher Rat für Landespflege 1997; Nutzinger 1995; Plachter and Werner 1998; Plachter et al. 2004a; Rat von Sachverständigen für Umweltfragen 1996).

Landscapes are highly dynamic systems over space and time (Farina 1998). For the European cultural landscapes, their past development was in no way a continuous process. Over thousands of years, they reflected the particular, locally very varied, interactions between the natural environment and human cultures. On repeated occasions, revolutionary inventions throughout history led to radical changes in landscape development over a very short time period.

The Neolithic revolution introduced crop cultivation (initially as shifting cultivation) and livestock farming, resulting in a new distribution of woodlands and open land, and increasing the influences of herbivores on the vegetation (Konold 1996; Küster 1995, 1998). The establishment of 'world empires' gave to rural landscapes the function of resource suppliers for the newly-arising large population centers. This led to a wide-scale devastation of woodlands and soils through the creation of extended nutrient-poor ecosystems (e.g., karst, garrigue in the Mediterranean region).

The transition from woodland landscapes to predominantly open agricultural landscapes in Central Europe in the Middle Ages marked another such 'leap'. Again, the technical revolution at the start of the 19th century abruptly changed the conditions for landscape development: chemicals and machinery were now the critical development factors (Emanuelsson 1988).

Today, the European landscapes, largely characterized by agriculture, are facing another comparatively drastic 'evolutionary leap' (Haber 1999; Mohr 1997; Plachter et al. 2004a). The driving force is the complex of factors known as 'globalization'. International markets create completely new conditions for the marketing and distribution of agricultural and forestry products. Farm output, which originally satisfied local needs (subsistence), then developed to meet regional demand in the urban centers and is now part of a global supply network. Without controlling measures, a particular agricultural product will only be produced in a part of the world in which, regardless of natural limitations, the production conditions appear in the short-term to be 'optimal' – with far-reaching consequences for nature. But even the controlling measures themselves, which should prevent a concentration in the most cost-effective production locations, can lead to problems. Economically and ecologically 'expensive' over-production in many parts of the world (including Europe) stands in contrast to permanent shortages in other parts. Above all, in the industrialized nations, and not only there (see tourism), the modern 'leisure society' is demanding a functional change in the countryside away from resource production and towards a higher quality of residential and recreational facility.

In many parts of Europe, these effects have already become manifest. Across large areas of the Mediterranean region, 'production areas' with adjacent 'dying' marginal areas with unfavorable production conditions are more evident than ever before. A similar situation exists with the high mountains and the so-called 'peripheral' or 'remote areas' with below-average production conditions in central Europe (see e.g., Beinlich and Plachter 1995; Isern-Vallerdu and Pedrocchi 1994). Frequently, further intensification with machinery and chemical substance application is seen as the only economical way to survival, with the result that even in those peripheral areas, the destruction of nature has advanced further, despite the awareness that these land uses do not really make sense anymore. The landscapes of Europe will be increasingly characterized in the coming years by a widening spatial disparity between 'favored areas' for agricultural production and 'peripheral areas' without a significant supply function (Bundesministerium für Ernährung, Landwirtschaft und Forsten 2000).

Over the centuries in Europe, variety in nature was a 'by-product' from agricultural land use. Since the technical revolution in the first half of the 19th century, this has no longer been the case (Bignal and McCracken 2000; Haber 1997, 1998a, 1999). Nature conservation and the management of species-rich landscapes, introduced just then, provide add-on benefits for societies, although being only of small relevance for 'normal' agricultural activities, and often even standing in contrast to them.

For Central Europe, abandonment of agricultural land has been forecast for decades, but until now has been realized only to a limited extent (Losch and Dosch 1997). In many regions, uneconomic farming activities continue to be carried out. The reasons for this are varied: a relatively high level of state subsidies (Germany, 50%, Switzerland, 69% of farm income), the opportunities for additional earnings and occupations in the relatively close population concentrations, and not least, the emotional connection of farmers to their chosen profession (Bundesministerium für Ernährung, Landwirtschaft und Forsten 2000). However, economic and social balances show clearly that such farming activity supported by capital resources cannot function in the long term. Because of a lack of financial means, and particularly in smaller farms, the farm machinery is hardly ever renewed and the next generation has shown little interest in taking over a bankrupt farm, particularly in the face of decreasing subsidies in the years to come.

But is not this a unique chance for nature conservation? For a long time, regions have been supported for production in which nature now could develop undisturbed. The protection of ecological processes, whether in the primary state or as a secondary product from areas released from land use, is one of the undisputed basics of nature conservation (Finck et al. 1998; Plachter 1996b). In northern America, this concept of 'wilderness' has a long tradition. In Europe, it is new in this form. But all ecological findings show that natural processes are a driving force behind the creation of biodiversity, even when they occur in previously-farmed ecosystems.

The dilemma in which the European system of nature conservation finds itself is that a large part of the biodiversity has relocated over thousands of years from (gradually destroyed) natural areas to ecosystems and landscapes characterized by farming use. What today exists as biodiversity has more or less become adapted to land use activities. Undoubtedly, these species can also exist in natural ecosystems, perhaps even more successfully. But for this to happen, the ecosystem must be already available and there needs to be an (ecologically dimensioned) time period for the 'renaturalization'. For communities in natural woodlands, this period can be measured over several centuries (cf. deadwood communities in planted oak pastures and mixed woodlands, which can arise following the end of agricultural activity).

There is therefore a huge discrepancy in time between the – desirable – creation of 'nature development areas' and the flexibility of the associated organisms to adapt to these new situations. This is particularly relevant to species which are reliant on areas of open land without tree growth. Fallow areas which arise now will quickly become overgrown with woody vegetation because of the very good nutrient supply (mineral fertilizers and atmospheric inputs). For new areas of open land to reappear in the course of tree succession, (for example, through phases of woodland decay, grasslands resulting from animal influences such as beavers, large herbivores etc.), whole centuries would be needed (cf. Beinlich et al. 1995). Where are these species to survive in the meantime? And how to aggregate continuous areas large enough to allow for undisturbed ecological processes? The current climate change constitutes another challenge for such a concept.

As things stand, there can be no simple nostrum calling for either 'wilderness everywhere' or 'open land everywhere'. The decision must be made in consideration of the location – and also dependent on finances (Deutscher Rat für Landespflege 1997; Phillips 1996; Rat von Sachverständigen für Umweltfragen 1996). The creation of 'new wilderness' only makes sense where the initial contamination level from nutrients, chemicals, tillage and the conditions for colonization of species within a foreseeable timeframe are either close to natural, and/or in such a state that species-rich ecosystems can be expected, or it takes place where such a development would never be more than deficient (for example, in some wooded areas, or lignite extraction sites). On the other hand, the preservation of a richly-structured, semi-open landscape is desirable in other areas. Here, the question of cost-minimization should not become subordinate (see also Riecken et al. 2004).

For a long time, practical measures with respect to nature conservation have focused on the preservation of typical, semi-open mosaic landscapes (Haber 1999; Plachter 1997; Schumacher 1995). An important instrument is the so-called contractual nature conservation system (individual agreements with farmers for financial compensation). Another instrument concerns stewardship arrangements for specific areas. Both solutions have significant disadvantages: they are comparatively expensive, their effects are too static in the case of stewardship plans, they fulfill no particular production objective although they 'harvest' biomass, they have a very limited integration within the structure of the existing agricultural enterprises, and because of the personnel limitations alone, they cannot be implemented on any particular area at will.

Until now, these nature conservation instruments have achieved good results. However, in the long run and for large areas, they won't reach their objectives if, as is to be expected, public financing continues to decline while at the same time, the area to be managed grows exponentially. If the predicted structural changes in agriculture turn out to be accurate for Central Europe, then it is already too late to give consideration to alternative development strategies. Current practice indicates that a part of the area would become afforested and the remainder would develop relatively quickly to form species-poor woodland succession. The resettlement potential for open-land species at the landscape level would reduce drastically in a very short time – along with the possibility of achieving alternative development strategies.

For those areas in Middle Europe in which the future model could be a 'semi-open mosaic landscape', alternative management forms will be necessary that are able to work effectively irrespective of the actual agricultural production conditions. The corner stones of such alternatives have to consist of: ecological efficiency (with respect to the protection of particular species, ecosystems and ecological processes), cost minimization, sensible utilization of the resulting biomass, the acquisition of additional revenues (for example, through quality products or tourism) and the personal identification of those involved (cf. Goodland et al. 1992; Hampicke 1991; Jaeger 1995; Rat von Sachverständigen für Umweltfragen 1996, 2000).

1.2
Ecological Effects of Livestock Grazing

A large part of what is today in Europe considered to be ecosystems particularly deserving of protection emerged out of historical livestock grazing, or were decisively influenced by it (Figs. 1.1, 1.2). This is just as true for the steppe-like shrub communities and scrublands (garrigue, macchie) of the Mediterranean region as it is for the grasslands of Scotland. The landscapes of northern Scandinavia are shaped by reindeer, kept in a semi-wild, nomadic way and 'ecologically controlled' by the local inhabitants.

The high elevations of the mountain regions of Europe have been used for thousands of years as summer grazing areas for livestock, with the result that woodland boundaries have been pushed down to form much greater open areas than would be possible by nature alone. In Central Europe, nearly all of the grasslands are used for livestock farming – the pastures for direct use and the cut meadows for the production of additional feed.

The Central European forests were also largely affected by livestock farming, on the one hand through woodland-pasturing and pollarding (producing foliage for extra feed), and on the other hand through the preference for particular tree types (for example, for acorn fattening) and the removal of the upper soil layer to mix with manure. *Calluna* heaths are the result of over-use through so-called 'plaggen' of the upper soil layer, where the aim is to produce more fertilizer with the livestock dung (Assmann and Falke 1998; Beinlich and Plachter 1997; Dennis 1999; Haerdtle et al. 2002; Radlmair et al. 1999; Redecker et al. 2002). The ecosystems that we currently protect in Europe are to a large extent the relicts of ancient grazing lands (see also Pott and Hüppe 1991; Vera 2000).

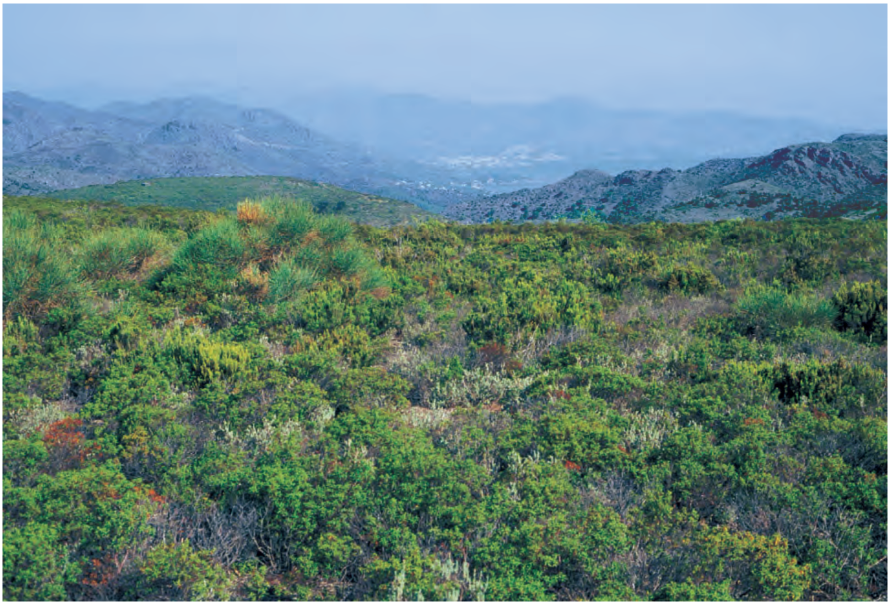

Fig. 1.1. In large parts of the Mediterranean region, abandoned grazing lands still shape the landscapes today. Garrigue in northern Spain (Cadaques) (photo: H. Plachter)

a
b
c
d

◀ **Fig. 1.2.** Grazing land in Central Europe. **a** Central Swabian Alb: calcareous grasslands with sheep grazing (photo: B. Beinlich); **b** park-like pasture with scattered trees (photo: Rückriem from Finck et al. 1997); **c** mountain pasture in the National Nark High Tauern/Austria (photo: H. Plachter); **d** woodland grazing in the Berchtesgaden National Park (photo: NP administration)

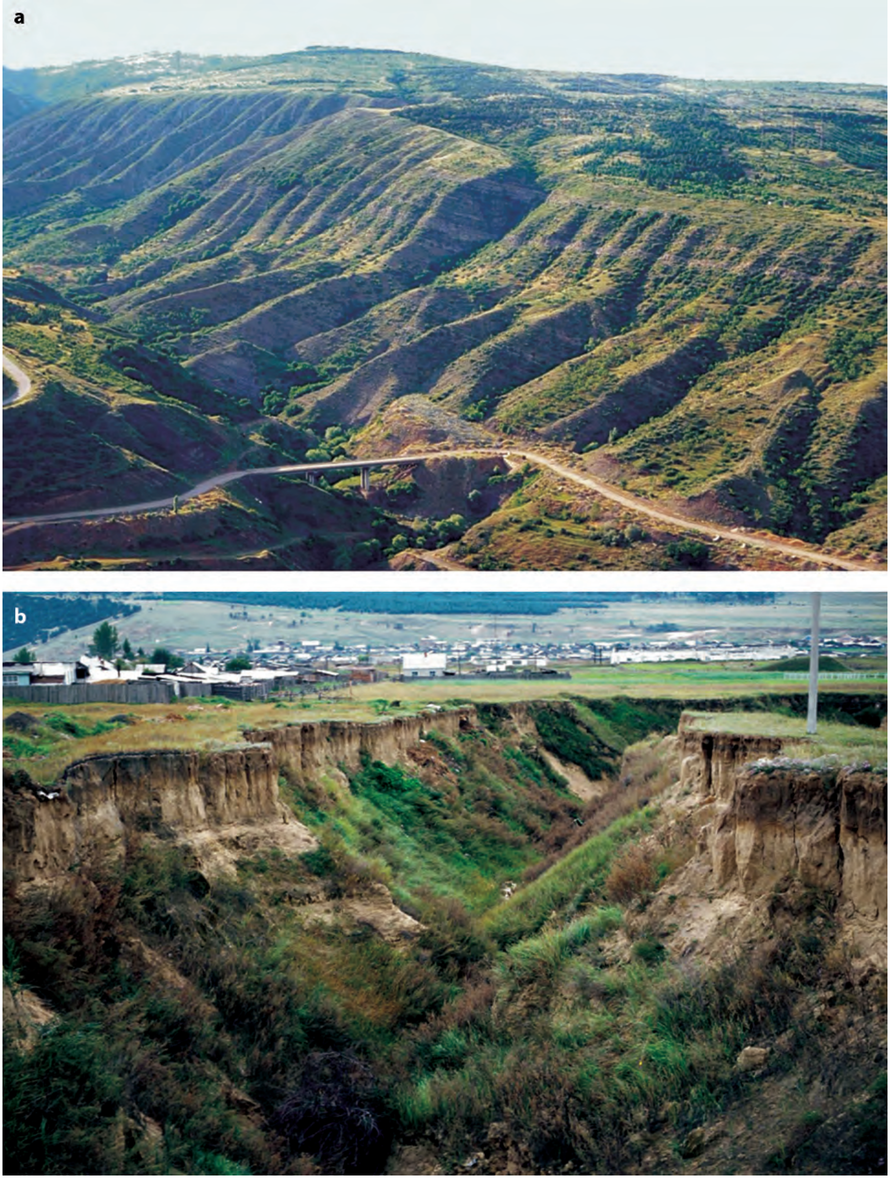

Fig. 1.3. Overgrazing, causing erosion in **a** central Georgia near Tbilisi (photo: H. Plachter) and **b** Buriatia/Russian Federation south of Ulan-Ude (photo: H. Plachter)

It stands to reason that strategies for the preservation of semi-open landscapes should take into account the factors which shaped these landscapes in earlier times.

On a global level too, livestock farming had and still has a major significance (Alexandratos 1995; Ehui et al. 1998; FAO 1995; Sere and Steinfeld 1996). At present, about 34 million km^2 of the land surface (= 26%) worldwide is used as grazing land and a considerable percentage of this is primary natural grassland (steppes, savannah etc.) (Milchunas and Lauenrot 1993). In addition to this is 3 million km^2 used for livestock feed production (Hendy et al. 1995; Steinfeld et al. 1997). It can be expected in the coming years that there will be a further clear increase in livestock farming, mainly in the developing countries (Delgado et al. 1999; Steinfeld 1998). For this to take place, however, there are no longer any suitable areas available, meaning that a further increase is only possible through intensification or an expansion onto basically unsuitable (and therefore only useful in the short term) areas.

Livestock farming is to a large extent responsible for the environmental damage that we find at the global level. Livestock contribute 5–10% of the emissions of greenhouse gases to the atmosphere, producing about 13 billion tonnes of waste each year, and although a large proportion of this can be returned to nature, modern stall husbandry can still result in serious eutrophication problems (Steinfeld et al. 1997). Over large areas of the planet, livestock farming has led to a clear increase in the extent of soil degradation in which erosion plays a major role (Nelson 1990; Oldeman et al. 1991) (Fig. 1.3). For example, over-grazing in the Sahel zone in West Africa was decisive in the spread of the desert and the resulting hunger affecting the local population (Thomas and Middleton 1994). In nomadic steppe-grazing systems, the livestock is in competition with wild animals, leading to the systematic extermination of the latter by humans (cf. the historical development in South Africa and the current population growth of the Saiga antelope in central Asia). The grazing of cattle on the site of earlier tropical rain forests has become a symbol of the destructive exploitation of nature (Faminow and Vosti 1998; Kaimonitz 1995). The global livestock numbers alone show that this form of land use cannot be sustainable on a world-wide scale (Table 1.1). Even without including poultry, the biomass of all livestock animals exceeds that of the world's human population.

Table 1.1.
World livestock populations and yearly meat and milk production for 1994 (FAO 1997)

Animal	Number (million)	Meat (million kg)	Milk (million kg)
Cattle	1 296.9	52 739	464 380
Buffalo	149.6	2 569	48 310
Camel	19.0		
Horse	60.7	493	
Sheep	1 089.8	7 188	7 782
Goat	613.2	3 150	9 983
Pig	883.4	78 537	
Chicken	12 568.0	51 223	
Total	16 680.6	195 899	530 455

1.3
The Situation in Europe

If one considers the historical documents, it becomes clear that the European development over time with respect to the effects of livestock on nature does also not stand in a good light. As early as the height of the Roman Empire, large swathes of land in the Mediterranean region were so over-grazed that any recovery could only be expected after thousands of years (Küster 1995; Schulz 2002). Continued livestock grazing has until now prevented this (Fig. 1.4).

It is not surprising, then, that livestock farming has a negative image with regard to nature conservation, (Fuls 1992; Gerken 1999; Irmler and Heydemann 1986; Klieber et al. 1995; Maertens et al. 1990; Plachter and Beinlich 1995; Radlmair and Laussmann 1997). However, it is often overlooked here that because of the specific developments and the current situation regarding the natural environment in Europe, global findings and assessments cannot simply be transferred to this continent. For a comparison with other parts of the planet, other aspects need to be considered, in particular, the following:

- An increase in food production is not necessary. In fact, there have been efforts for decades to reduce production excesses.
- Decreasing revenues and the internationalization of the markets have resulted in farming in many regions in Europe (and a higher proportion in mountainous areas) becoming unprofitable; increasingly larger areas have given up farming after centuries of activity.

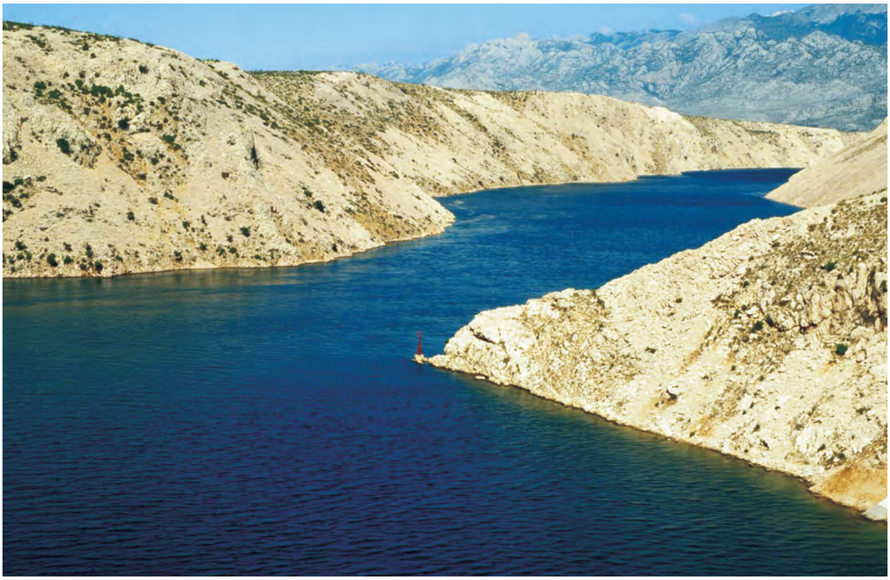

Fig. 1.4. Croatian landscape at Zadar, which arose through over-pasturing since the time of the Roman Empire. A gradual recovery could have been possible but was prevented by permanent livestock grazing (photo: H. Plachter)

- New requirements affecting the European cultural landscapes are taking greater prominence, particularly the protection of continental biodiversity, recreational factors and the production of quality, environmentally-friendly goods; structurally diverse, semi-open mosaic landscapes fulfill these demands in many cases but require constant interventions from humans and/or herbivorous animals.
- For historical reasons (species depletion during the ice age) and previous forestry activity (promotion of coniferous trees), uncontrolled successions in Europe often result initially in comparatively species-poor ecological conditions.
- Whereas in other parts of the world, nutrients at the agricultural level remain in short supply, the European landscapes are widely eutrofied (fertilizers, atmospheric emissions etc.). In many areas of Europe, therefore, the protection and recovery of nutrient-poor ecosystems is an important objective. In this respect, even 'degrading' land uses, which would be totally unacceptable in other parts of the world, can make a significant contribution.
- The large-scale management of such landscapes brings with it considerable costs, which may be justifiable from the point of societal objectives, but need to be kept as low as possible on economic grounds.
- Given that the agricultural and forestry forms of the past in Europe tended to result in a relatively biodiverse spread at the landscape level, there are advantages in integrating elements of this land use in current management systems. In general, interactive uses between local production and naturally 'planned' and/or technically based variants are preferable.

In the Central Europe of historical times, two factors were lacking in agricultural production before the invention of chemical fertilizers and petrol-driven machines, both of which limited production in the sense of the much later developed 'Liebig's Law': human labor and the availability of nutrients. The first factor fluctuated strongly in the course of history (see population development in the last 2000 years), and the second was determined by the creation of new soil in the particular location. However, there were technical 'resorts': through grazing, the livestock were able to take up additional nutrients in natural ecosystems and in what were for those times, extremely complex transfer systems, deliver these to the existing crop cultivations (Fig. 1.5). Historically, agriculture in Europe was in this respect a continuous compromise between a, for all intents and purposes, conscious degradation of the semi-natural ecosystems

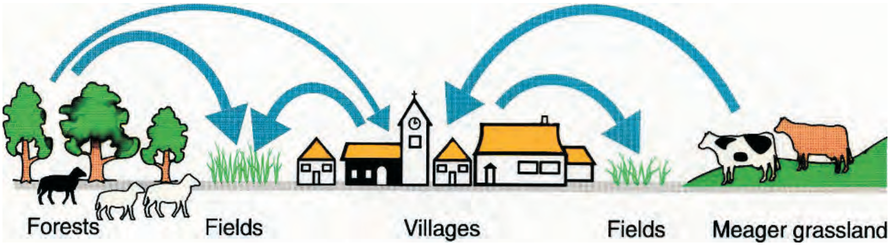

Fig. 1.5. Sufficient agricultural production in Europe's historical landscapes was only possible because nutrients were taken up from semi-natural ecosystems and transferred to arable land. This resulted in an unavoidable ecological degradation of many natural ecosystems

(see old land use laws which were passed to control over-use) and the necessity of producing plant products from crops with a sufficient degree of continuity.

A land use technology of this type, in which domesticated animals serve as a 'motor' for substance and energy transfer between (over-pastured) semi-natural ecosystems and agricultural crop systems seems at first glance to be very distant from the modern principle of 'sustainability' (see Haber 1998b for more on this). Without doubt, most natural and semi-natural ecosystems were 'damaged' in the course of time as their nutrient basis was removed. Additionally, the (long term) economical and social sustainability of such a land use may rightly be questioned. And yet, it is exactly this situation (albeit not alone) which created a comparatively high biodiversity, given the location in a temperate climate zone with rather fertile soils.

1.4
Specific Characteristics of European Cultural Landscapes

For an appraisal of the phenomena described here, the following aspects have to be given particular consideration in Europe:

1. In many parts of the world, agricultural landscapes are – in comparison to the natural situation – noticeably low in species. There can be no doubt that current land use forms can be considered a serious intrusion into natural processes, particularly as species worthy of protection are in the meantime, barely in existence (Fig. 1.6). The situation is different in large parts of Europe and in a few other regions of the world: although likewise continuously farmed, and although crop cultivation is carried out to the same intensity, these landscapes are characterized by a level of biodiversity on a landscape level (gamma diversity) which is very high – sometimes higher than would be the case if the land remained uncultivated. Therefore, European rural cultural landscapes have a significantly higher nature conservation value than landscapes similarly characterized by agriculture in other regions of the world. There are few attempts at an explanatory analysis with regard to this finding. Perhaps it is simply the disproportionately longer time period in which the development of technology and changes in nature have had to act on each other in these landscapes, in the sense of an interacting co-evolution (cf. Plachter 2004): the developing cultures had to take into account the local conditions in their technical considerations, and nature 'had time' to adapt itself to the changing ecosystems. It is noticeable that many species with high demands on their environment are able to survive in European cultural landscapes and there would have been more if hunting had not driven them out, particularly with respect to larger mammals. Most of these surviving species now have several hundred generations of human influence behind them – a period which could be sufficient for necessary adaptations in learned behavior as well as in the genetic types. The situation is quite different with respect to 'third world' agricultural landscapes; modern land use technology with complete structural changes, chemicals and machines were introduced here abruptly, without consideration of local factors and without an 'adaptation phase' for nature (Fig. 1.6).
2. Within the framework of the comprehensive discussions over the global political objective of 'sustainable development', the spatial dimension of the problem has

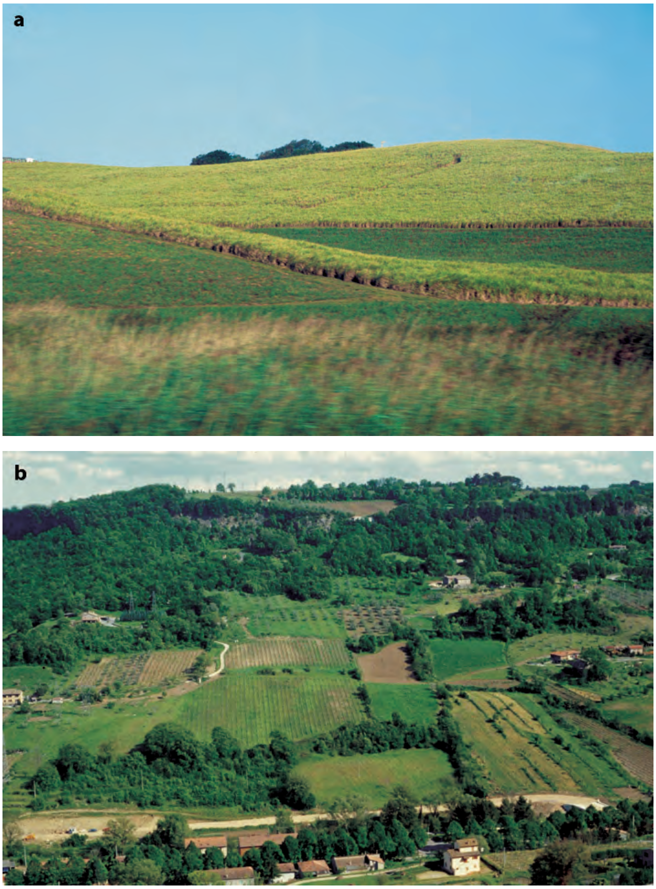

Fig. 1.6.
a Species-poor 'sugar cane landscape' in South Africa, north of Durban (photo: H. Plachter) and **b** species-rich mosaic landscape in Bologna/Italy (photo: H. Plachter)

only rarely been broached. The concept of sustainability implicitly includes the utilization of the biosphere by humans. Wherever this utilization takes place, it leads to a negative intervention in nature at the corresponding spatial level, with respect to ecological principles. A cereal field with the usual farming methods which are practiced today could never in itself be considered 'ecologically sustainable'. However, within the context of a landscape, it can be a part of an optimized compromise between nature conservation, economic and social objectives which supports the proposition of sustainability. It obstructs natural succession but can support a higher level of biodiversity on the landscape level by offering habitats for additional species. Sustainability does not mean the maximum renouncement of land use, but rather an optimization between short term agricultural requirements for humans and the simultaneous preservation of ecological regeneration and regulating functions. The implementation of 'sustainable development' is primarily a scale problem. Thus, the importance of European cultural landscapes for nature conservation correlates strongly to the observed spatial level. If one applies the customary field-ecological method of analysis which is normally used for point studies or localized studies, a rather negative picture results: individual areas are just as species-poor – compared to the natural situation – as in other parts of the world. This is different at the landscape and the regional level. Because of the widely diversified mosaic character, European cultural landscapes achieve the level of diversity of more homogenous natural landscapes in other parts of the world or even exceed them (Fig. 1.7). Nature conservation strategies in Europe are consequently tied to the spatial level of the landscape or region. The point here is the preservation of diversity at these high spatial levels – at the landscape level, through support of ecological and use-determined gradients and at the regional level through the diversity of different, locally-adapted forms of land use. This creates a particular challenge for both ecological research and for the process of setting functional nature conservation objectives.

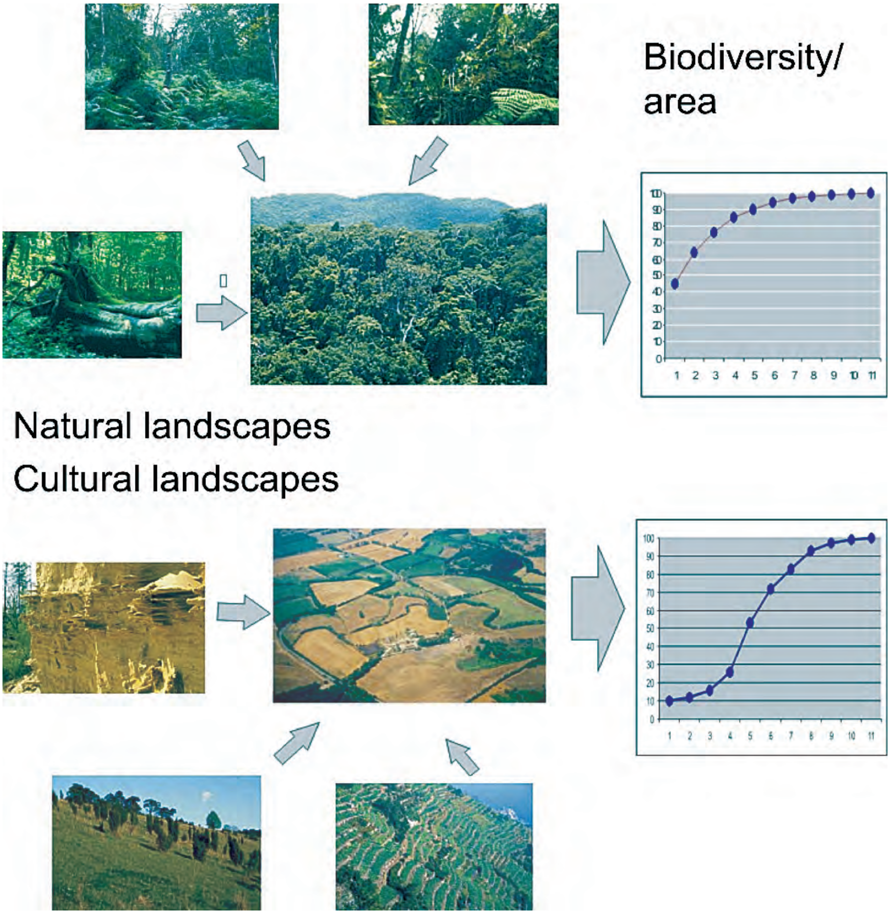

Fig. 1.7. General differences between natural landscapes and cultural landscapes arising out of a co-evolution of humans and nature, with respect to their biodiversity at the particular spatial levels (from Plachter and Puhlmann 2004)

3. Traditional livestock grazing implicitly involves the degradation of the grazed ecosystems with respect to soil quality and the development of vegetation. However, this is no different to natural ecosystems dominated by herbivores, such as savannah or steppes. Here also, there is a dynamic equilibrium between maximum grazing and the population numbers of the grazing animals. Where there is long term 'under-grazing' on steppes, shrubs and woodland expands resulting in an increasingly deteriorating nutritional basis for grazing herds. The nature conservational evaluation of such a 'degradational' form of use is, however, very different in various parts of the world and also in the historical temporal context. For a long time, Europe's landscapes have been exposed to an area-wide excess of nutrients, caused by the over-use of fertilizers in agriculture and nutrient inputs from the atmosphere, among other things. It can be shown that as a consequence, species of animals and plants being competitive under less nutrient supply have for decades been more seriously threatened (Ellenberg 1985). Without doubt, it is a basic objective of nature conservation to preserve the whole spectrum of natural assets in a landscape. If nutrient-poor local conditions go into decline, as is happening in large parts of Europe, then it will be necessary to find strategies to recreate such conditions in some of these areas. Nutrient-removing land use forms, although undesirable in other parts of the world and also in earlier systems in Europe, could certainly be a sensible strategy with respect to present-day conditions.
4. The requirements of 'consumers' with respect to agriculture have undergone basic changes. Increasingly, there is a demand for high quality 'healthy' products with minimal impacts to nature, locally-produced goods and the 'management' of landscapes for recreational purposes. This means a basic paradigm shift in agriculture from a monofunctional, food-producing role to a multifunctional production industry in which local objectives can be in the foreground. In this context, the general perpetuation of the historical production targets is just as narrow an approach as the vision of some conservationists of the 'farmer as landscape manager'. The particular objective of the farm must be oriented to the local situation, but also to the principles of a 'sustainable land use and development'. Strategies are needed which serve to supply human requirements and at the same time, give maximum preservation to nature.

1.5
Livestock Grazing: a 'Sustainable' Development Perspective?

'Sustainable development' is defined as the optimized compromise between the ecological, economic and social requirements of a region (Goodland et al. 1992; Haber 1998a; Jaeger 1995; Henne et al. 2003; Plachter et al. 2004b). Human exploitation of the biosphere is therefore an integral component of the sustainability theorem. However, two constraints have to be given greater prominence than previously: the (economically cost-neutral) use of ecological outputs and the determination options of future generations. 'Sustainable' land use forms should as a consequence, integrate ecological processes as far as possible and should avoid developments that are irreversible in the foreseeable future.

Against this background, the livestock grazing of ecosystems can be considered in the light of the following:

1. With respect to their behavior, and therefore their ecological effects, domestic livestock are relatively close to their ancestors. Given that wild herbivores also decisively influenced the natural landscapes of Europe, livestock grazing is a semi-natural exploitation of nature and in any case, much more natural than any form of crop cultivation.
2. Because of spatial-temporal differences in the behavior of livestock, they can create local effects which can be classified as a 'non-sustainable' over-use. However, at the landscape level, such effects are for all intents and purposes acceptable when they create overall a varied mosaic of local qualities. In hypertrophied landscapes, they are even desirable in preserving habitats for low-nutrient pioneer species.
3. Wild animals would perhaps produce even more ecologically natural processes but the effects would need to be balanced against a clearly reduced availability of the consumable animal biomass, with respect to the principles of 'sustainability' mentioned above. In addition, the use of wild animals, or semi-wild domesticated animals would mean that the aims of traditional, production-oriented farming are completely lost. Care has to be taken that 'sustainable development' includes here the sensible exploitation of natural resources. If a particular management alternative cannot support these principles, it should be restricted to special areas (for example, the gradual renaturalizing of areas which are in a sensitive ecological state because of massive human interventions: opencast coalmining, drained mires, etc.).
4. It is clear that modern variations in outdoor livestock farming (generally in connection with managed grazing) allow only a low level of diversity. Set against this is the finding that the predominant part of what today are considered as ecosystem types worthy of protection were grazed in historical periods. The available data indicates that the type of grazing management (the extent of behavior-based effects of the livestock) and the surface area of the grazing land are able to explain these discrepancies. There is up to now, however, a lack of causal evidence to support this.
5. If particular forms of livestock ranging could actually make substantial contributions to the objectives of nature conservation, then these would have to be classified as especially sustainable forms of use and there would be positive ecological effects with simultaneous economic and social integration within the particular agricultural production system. Livestock would then be able to make a contribution to society's desired aim of a varied cultural landscape with recreational dimensions, and also to the creation of high-value environmentally-friendly agricultural products.

Although livestock grazing has to be judged in a rather negative light within the global context, its proper application in Europe can make a significant contribution to nature conservation and to the development of landscapes that meet the current demands of society. Against this background, it is necessary to examine where and in which form livestock grazing can make a meaningful contribution to the management of the European landscapes. This question has to be answered in consideration of local specifics and cannot be approached in a general sense. However, it should be possible to develop decision algorithms which would make it easier to arrive at appropriate accords within the regional context.

1.6
Grazing As an Instrument of Nature Conservation

Within the last ten years, grazing has increasingly been included in discussions on nature conservation instruments (Redecker et al. 2002; Finck et al. 2002). Earlier, it had been considered a negative factor in comparison to other land use forms such as meadow mowing or management measures such as mechanical bush removal. More recent findings have supported the idea of turning away from this negative approach and integrating different grazing regimes in nature conservation concepts.

- The large number of endangered ecosystem types which had arisen through livestock farming only gradually became clear over time. It was suggested that at the least, a selective reintroduction should be considered, but this had to be first of all put into perspective against centuries of prejudice against grazing.
- One of the few 'historical' husbandry forms which has survived in fragments in Central Europe is sheep grazing, now carried out mainly within the so-called 'stationary shepherding' system. Even today, it provides significant contributions to the maintenance of poor, dry grasslands (such as the calcareous grasslands of the low mountains in Central Europe) and the heathland plains, although the system became increasingly unattractive from a social and economic point of view in the 1980s and 1990s. This means that a significant management factor is in danger of becoming lost.
- Because of the structural changes in agriculture, a rapidly growing number of areas had to be maintained through nature conservation management. New programs (conservation agreements, landscape stewardship programs) initially made a passable attempt at covering the costs arising but it was foreseeable that soon, only a part of these areas could be preserved in a particular condition in this relatively costly way.
- The ecological models have changed considerably in consequence of adapting to the corresponding objectives of nature conservation. Initially, a static deterministic model was preferred. Now, however, integrated concepts such as dynamic change, dynamic equilibrium and random (stochastic) disruptions have a central role. All of the current models which are relevant to nature conservation contain such components, for example, the metapopulation concept, the concept of the minimum viable population size and the mosaic cycle hypothesis. In this way, factors such as succession, disturbance – even the concept of naturalness itself – have all experienced a significant change of interpretation.
- With the recognition that populations of species and ecosystems need particular forms of 'disturbance', livestock grazing itself now appears in a new light. In an ecological sense, such disturbance variables in the form of wild herbivores are able to influence ecosystems in many areas of the world and therefore preserve these and possibly the complete spectrum of typical species.
- On this basis, there has also been an extensive discussion about the natural significance of large herbivores in Central Europe. These may have been seen as a factor which obstructed natural development in the 1980s (see damage caused by game in woods) but later, a different attitude was to prevail. Most of the large herbivores such as bison, wild horse, aurochs and elk have long disappeared from the Central

European landscapes. It is questionable as to what effects they would have had under natural conditions on woodlands and landscapes. The assertion by the proponents of the so-called 'large herbivore theory', that considerable parts of Central Europe would have been a semi-open park-like landscape with scattered woods (cf. Bunzel-Drüke 1997; Vera 2000), stands in stark contrast to the 'classical' woodland model of phytosociology.

In the totality of the arguments, particularly with regard to cost efficiency and the degree of orientation to nature of the 'disturbance form', the discussion on grazing and nature conservation has increasingly concentrated on semi-wild or wild forms of husbandry, or at least 'robust' livestock breeds which require only a small amount of care. The first experiments with 'wild' husbandry – the so-called Heck cattle (from domestic 'breeding back' of aurochs) and non-demanding horse breeds – were very promising in the Dutch Oostvadersplassen reserve (Bunzel-Drüke 2004; Kampf 2001; Sonnenburg and Gerken 2004; van Klink and Kampf 2004). The associated problems concerning the availability of large continuous areas, or the legal aspects of animal welfare or animal diseases, remained in the background. One of the significant key ideas arising from the new concept is that of an 'extensive, wild to semi-wild all-year outdoor husbandry'.

In the meantime, wide experience from a whole series of studies has become available (Bokdam and Gleichman 2000; Hochberg and Finke 2004; Luick and Bignal 2002; Plachter et al. 2004a; Reisinger 2004; Satzger 2002; Schumacher 2004; Schwabe et al. 2004). This covers various forms of keeping ranging from 'wild' to 'similar to domestic animals', species and breeds (cattle, horses, sheep, pigs) as well as assortments (for example, horses and cattle together). Under appropriate basic conditions, practically all these variants can be justified. However, none of these variants can offer a panacea or a general solution to the preservation problems described. Which variant leads directly to the desired objectives must be decided on the individual merits and is dependent largely on the character of the particular landscape. For example, for an original wilderness area, it is necessary to select a different grazing regime than for the preservation of a historical cultural landscape or for the protection of particular habitats or species.

1.7
For and against 'Extensive' Grazing Variants

Most of the new grazing variants described above as methods of practical nature conservation were supplied from the authors with the predicate 'extensive', without really defining sufficiently what is exactly meant by the term. The Duden dictionary gives a definition of the concept as: "with minimum application of labor and capital" (Duden 1996). The following definitions are found in English publications: "covering a large area; large in amount or scale" (Compact Oxford English Dictionary; *www.askoxford.com* 2005), or "1. *large in amount*: great in amount or number; 2. *broad in scope*: great in extent, range, or application; 3. *vast*: covering a large area; 4. *agriculture using low technological input*: relating to a farming practice in which a large area of land is cultivated using little labor and expense, resulting in a relatively small crop" (Encarta World English Dictionary, North American Edition; *http://encarta.msn.com* 2006).

Irrespective of the clearly differing meanings in the German and English language usage, the term extensive cannot be applied as a general predicate, but must always refer to definite influencing variables. A particular utilization form can, for example, be extensive with regard to the use of farm resources (such as chemicals, machinery), personnel time and effort, costs or ecological effects. If all these parameters act simultaneously, then it is practically ineffective. In British-English language usage, extensive refers mainly to the size of the land. 'Extensive grazing' is therefore to be understood as large area grazing, without any further definition relating to livestock densities or ecological effects.

If one analyzes the relevant publications in more detail, it becomes clear that under the term 'extensive', the individual authors attribute very different qualities with respect to the grazing system in question. Some assume the input of very low levels of operating resources and personnel work (no mineral fertilizers or crop protection products, no mechanical ploughing of fields, 'semi-wild' husbandry) and others refer to a comparatively low stocking density per unit area. In addition, most authors presume that the named factors correlate positively with each other, which does not in fact accord with either the practice of a properly regulated grazing regime or to the desired nature conservation objectives. Not uncommonly has a carelessly used attribute such as 'extensive' obstructed an objective discussion about a promising instrument for nature conservation, as in the case of grazing with herbivores.

The sense of grazing with livestock, as with wild animals is to prevent a naturally occurring succession to trees and woodlands from taking place. It is necessary therefore that grazing should imitate or substitute a major ecological disturbance. If we look at the corresponding literature more closely, the suspicion arises that the predicate 'extensive' is not used in an explanatory way but rather by way of apology, perhaps in the sense: "yes, we want to look after the land, but we don't want to break anything. This is what we call extensive". However, it is exactly this that the management task of grazing cannot become. It should be destructive, at least as far as woodland succession is concerned, and it should create obvious areas of disturbance in the vegetation, for example, through the grubbing of pigs or the trampling of cattle.

If grazing is to be used efficiently as a management tool, it will be necessary that it allows for the unfolding of recognizable effects on the grazed areas. With regard to effects, it must be 'intensive', either at the micro-level (by creating local habitats) or at the meso-level (through the long-term preservation of unwooded open land). All anthropogenic grazing systems in the world come down to two components: the effects of livestock itself and the additional mechanical interventions of humans in pursuit of 'pasture management' (such as the removal of young tree growths, control of plant-eating competitors, and in Central Europe, the secondary benefit of the use of wood for fuel, mulching and post-mowing). Because the natural tendency to develop into woodland is very strong in most areas of Central Europe, any management strategy to preserve un-wooded ecosystems will need to be correspondingly intense. For grassland, there are in principle three basic interacting approaches, which can be varied according to the local conditions: *(a)* the influence of herbivores, *(b)* human mechanical interventions in vegetation growth, and *(c)* natural disturbance events such as flooding or fire. The more 'extensive' any one of these three factors works, the more intensive one of the remaining factors has to be.

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Chapter 2

Extensive Livestock Farming – an Alternative Form of Nature Conservation Management?

Harald Plachter

2.1
Initial Situation

Our knowledge about the effects on nature in temperate climate zones of livestock grazing and the grazing of breeds and species of animals similar to livestock has improved a lot in the last few years (see e.g., Beinlich and Plachter 1995; Finck et al. 2004; Redecker et al. 2002). However, several consistent problems have to be considered in the appraisal of the available studies:

1. The duration of almost all of the projects has until now been too short to allow for a sufficiently long-term assessment of ecological consequences. In many cases, short-term results say very little about long-term effects. In particular, it must remain open as to how large can be the formative influences on the development of woody species (cf. Seifan and Kadmon 2006; Weber and Jeltsch 2000).
2. It is obvious that not just the local combination of site factors, but also the biological preconditions of the area have significance for the type and extent of effects. There are here a wide range of studies from various parts of the world, particularly concerning the effects on vegetation (e.g., Adler et al. 2001; Cingolani et al. 2003; Huntley 1991; Milchunas et al. 1988). However, corresponding works in Europe are until now largely absent.
3. Most of the studies were carried out under the constraints of research projects. Specific cost factors applying to 'normal operations' are not incurred and other additional costs arise only through the experimental design. There is a lack of realistic economic accounting of the costs as well as robust data covering the marketability of the product (in the case where this may be desired).
4. There is a lack of data on the extent to which most of the variables in existing agricultural enterprises can be integrated. Where this is not given, the practical applicability is seriously limited to projects initiated and financed by nature conservation institutions themselves. It is also unclear as to what extent in particular, semi-wild forms of husbandry would be acceptable by the farmers themselves.

2.2
Extensive Grazing with Local Livestock Breeds

A number of works in the last few years have supported the concept of a semi-wild or wild herbivore husbandry, mostly concerning wild animals (deer in enclosures, bison) or 'primitive' domestic breeds or 'bred-back wild forms' such as Heck cattle and Exmoor ponies (Bunzel-Drüke 2004; Kampf 2002; Sonnenburg and Gerken 2004). Another starting point for the application of grazing animals in nature conservation is the use of already existing local livestock breeds, but in different husbandry forms optimized to benefit nature conservation objectives (Hochberg and Finke 2004). Against the disadvantages of the reduced naturalness of the system with respect to semi-wild husbandry, there are advantages in the ease of integration into agricultural enterprises and the better marketability of the animal product.

Against the use of 'normal' livestock breeds as management measures in nature conservation, there are reservations that the particular species or breed would not be able to fulfill their functions necessary for an effective and targeted control of nature development, with respect to their living requirements and behavior. However, a closer examination of the facts shows that such conclusions are always based finally on 'modern' husbandry forms and not on the breeds as such. The present-day, extremely limited grazing management systems are however neither comparable with the historical situation, nor do they adequately allow for the possible behavior spectrum of the livestock which could be achieved under other husbandry conditions. Our understanding of the ecological effects of 'normal' but locally adapted livestock breeds over a wide range of husbandry forms, as was common earlier, is decidedly limited.

Since 1993, we analyzed and evaluated the applicability of conventional livestock species and breeds for conservational aspects in a series of research and development projects. Comprehensive results of sheep husbandry in station shepherding systems have already been published (cf. Beinlich and Plachter 1995) so it is only necessary here to consider these findings where they are needed for a better understanding of the conclusions in Chap. 9. The focus of the following chapter is on a project on large-scale cattle farming in the years 1999 to 2004 which was financed by the German Ministry for Research and Education (BMBF) and was aimed at 'opening up landscapes'. A number of other projects, particularly concerning reference areas in other countries, were networked to this project (Plachter et al. 2004) (Table 2.1).

All projects followed a common concept which can be described with the following basic premises:

- a focusing on 'normal' species and breeds, which are currently used in agriculture;
- validation of the ecological propositions through economic accounting as well as identification of the key parameters which are decisive for the viability of different grazing variants;
- the use of modern processing systems (GIS, scenarios);
- parallel analysis of the effects on different spatial levels (micro-level up to landscape);
- detailed, comparative behavior studies of livestock dependent of the size of the pasture and other husbandry conditions;
- reconstruction of the historical effects and with regard to (re-)introduction, the expected effects of such forms of livestock keeping through reference investigations in very large grazing areas in different parts of Europe (Georgia, Ukraine, Sweden);
- the development of grazing models in the German low mountain ranges (Swabian Albs, Rhoen, South Black Forest) and validation of the transferability of the results.

Table 2.1. Research and development project on extensive livestock grazing, of which the results are shown in this book

Project	Duration	Sponsor	Partners	Main objectives
A nature conservation concept for calcareous grassland of the Central Swabian Albs (Baden-Württ.): protection, use and development	1991–1994	Environment Ministry Baden-Württemberg	District President Tuebingen	Stationary herding of sheep; history, ecological effects; economic business analyses; recommendations for action
Development concept for the upper Dnister region/Western Ukraine; TP grazing	1996–1999	German Ministry for Education and Research (BMBF)	University Lviv, Inst. Zoology and Botany	Shepherded cattle keeping in subsistence farming; historical analyses; ecological effects
Large-scale, stochastic effects of cattle grazing as a development alternative for the Central European low mountain ranges	2000–2004	German Ministry for Education and Research (BMBF)	Oeland: Ecological Station, Univ. Uppsala	Stationed cattle and sheep husbandry on large pastures in the Rhoen mountains, Black Forest and in Oeland/Sweden; method development; spatial analysis; economic analysis; mathematical model; scenarios; recommendations for action
Outdoor experiments on large-scale cattle husbandry in the Thuringian Rhoen	2001–2004	Thuringia Nature Conservation Foundation	Biosphere Reserve Administration	Experimental large-scale continuous grazing in comparison to rotational grazing; ecological and economic analyses
Livestock ranging in Georgia (Caucasus)	2000–2002	German Research Foundation	State Agricultural University, Tbilisi	Countrywide development over 50 years; shepherded cattle husbandry in the low mountain ranges

Livestock grazing on large areas, particularly with cattle, has virtually disappeared from the Central European low mountain ranges. The corresponding effects on nature can now hardly be investigated in this area. It is true that an experimental reintroduction, as was practiced in the Thuringia Rhoen, could yield important results. However, long-term effects from such an approach cannot be analyzed. In earlier times on the other hand, extensive livestock grazing was widespread in Central Europe (cf. Finck et al. 2002; Plachter 2004). How this exactly functioned is not clear and there are only rough ideas, some of which are colored with romanticized interpretations. The breakdown of the Soviet economy, which had already began in the 1970s and 1980s, and the more or less complete return to subsistence production based largely on bartering, opened up the possibility of studying two peripheral reference areas in Eastern Europe with respect to the grazing systems which resulted from these events (Didebulidze and Plachter 2002; Horban et al. 2000). The reasons for choosing the areas in western Ukraine and Georgia are given in Table 2.2.

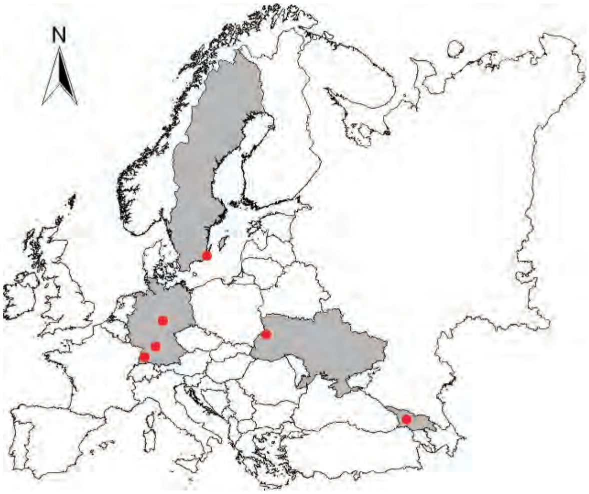
Table 2.2. Characteristics of the investigated areas

Area	Investigated grazing types	Climate	Rationale	Other data
Central Georgia	Shepherded pasturing with cattle	Sub-continental – semi-arid	Low mountain ranges at Tbilisi with subsistence cattle farming; pasture of two communes on a butte mountain	Structured interviews; livestock development in Georgia over 50 years
West Ukraine	Shepherded pasturing with cattle	Sub-continental – temperate	Low mountain ranges (basalt/lime-stone); mat-grass (Nardetalia); Allmende commons grazing	Land use development of a commune over 100 years
Oeland/Sweden	Set stocking, cattle and sheep	Sub-continental – temperate	Despite planar relief, similar climate to low mountain ranges; EU funding conditions; grazing since 5 000 years, in current spatial structure, 200 years	Farm economy
Rhoen	Set stocking and rotational grazing of cattle; Stationary herding of sheep	Sub-continental	Low mountain ranges (basalt/lime-stone); mat-grass; biosphere reserve *(a)* Hesse: rotational grazing, structural persistence of Allmende commons grazing pastures; *(b)* Thuringia: experimental set up of extensive set stocking with cattle	Financial analyses of farms; scenarios for future development; decision-making grid for areas suitable for restoration of extensive grazing
South Black Forest	Rotational grazing, cattle	Sub-continental	Low mountain ranges; acid soils; structural persistence of Allmende pastures	Working time studies over 5 decades
Middle Swabian Albs	Stationary herding of sheep	Sub-continental	Low mountain ranges; extended calcareous grasslands of high quality	Economic analyses; identification of key parameters for management; recommendations for earnings improvements for shepherds

Of course, these types of subsistence production systems are not transferable on a one-to-one basis to Central and Western Europe. However, they give important information about how the conditions of the ecosystems and the range of species to which we afford priority protection in those European areas came about. Individual elements of these 'historical' grazing systems may have a value in being integrated into current management systems.

However, the question remains open as to the extent to which extensive grazing forms can be viably achieved under the agri-structural framework conditions of the European Union. The southern part of the island of Oeland, where for thousands of years, large-scale livestock farming has been carried out on the 'Alvar', offers an excellent example for this purpose. In addition, the composition of fauna and flora is very similar to that of the Central European low mountain range areas, resulting from the unique local climate and its biogeographical history (Rosen in this book, Sterner 1986).

Fig. 2.1.
Location of investigation areas



Oeland already belongs to the EU, the countries of the Caucasus are members of the Council of Europe (for more information, see 'European Landscape Convention under *www.coe.int/t/e/Cultural_Co-operation/Environment/Landscape* 2006) and western Ukraine has shifted closer to the EU following the eastwards expansion. If livestock grazing is to be recognized as an important instrument in landscape management, it will have to be properly regulated in the future within a consistent European framework. This will include forms of direct and indirect financial support. Then, it has to be made clear which variants have conservation value, and therefore should be assisted, and which do not.

Given the current state of knowledge, the reference areas in Eastern Europe and in Sweden have served for ecological and economic analyses, and – in the case of Georgia – also little sociological analysis. Definite recommendations for action have only been developed for the German investigation area (Fig. 2.1). However, the relevant conceptual considerations are transferable, with certain adaptations, to other European landscapes.

2.3
Effects at Different Spatial Levels

Grazing has effects on quite different spatial levels. Also, the term grazing applies not only to the effects of cropping vegetation, but includes all the other manifestations of the animal's presence, such as trampling, nutrient redistribution, diaspore spread and grooming which may temporarily occur (perhaps through the sunlight penetrating to ground level) or affect the nutrient balance (depositing of dung and urine):

- On the 'meso-level', for example, on pastures, through the reduction or expansion of an existing local habitat spectrum or through the redistribution of nutrients;
- On the 'macro-level', for example, the farmed land of a commune or a section of landscape, through the temporal-spatial configuration of pastures, the transport of dispersion units (diaspores, transferred animals) through livestock or the necessity of cultivational activity including grassland management to provide feed for the livestock.

The discussion about the advantages and disadvantages of livestock grazing is frequently made more difficult, sometimes to the point of absurdity, through the poorly considered comparison of effects at different spatial levels. What may seem a major intervention at the micro-level, such as a local soil denudation through trampling damage to the vegetation, can make a substantial contribution to enriching the habitat spectrum at the meso-level. A pasture could be relatively species-poor at the meso-level and may continue to function only through the supplementary supply to the livestock of fodder from meadows, but at the same time may contribute significantly to the biodiversity of the section of landscape, that is, at macro-level.

It is in no way just the spatial complexity which makes an appraisal of the grazing systems so difficult; to an equal measure, the very dynamic time factor is also problematic. In Central Europe, existing species have to be able to compensate for severe changes in environmental conditions in the course of the seasons. Their requirements for survival have become correspondingly specialized. There is need for specific resources to be available at exactly the 'right time'. For most amphibian species, it is sufficient if their specific needs regarding standing waters are available for three months of the year. Nectar-seeking insects require an adequate 'basic supply' during the activity period.

Table 2.3. Development and improvement of meso-scale temporally high-resolution surveying and analysis procedures. In addition, 'conventional' procedures such as transect surveys and point source visual observations were used

Method	Objective	Application
Kite aerial photography	Changes in vegetation structure in the course of grazing	Rhoen
Opposite slope photography	Behavior of livestock and effects on habitat structure	South Black Forest
Habitat diversity from presented aerial pictures (automatic segmenting)	Structural diversity of grazing in comparison to other landscape elements	Rhoen
Visual registration in narrow time intervals (time sampling), in part with integration into the flock	High resolution flock behavior	Georgia, Ukraine, Oeland, Thuringia, Rhoen
GPS collar with data logger on leader animalsaH	Day series of flock behavior on large area	Oeland
Cow pat density	Indicator for grazing density of cattle on the pasture	Ukraine
Area-wide survey of vegetation parameters and animal species in categories	Spatial-temporal changes to habitat resources	Georgia, Ukraine, Rhoen, South Black Forest
Historical maps/aerial photos; community records	Reconstruction of long-term development of the pastures	Ukraine, Hessian Rhoen, South Black Forest; Swabian Alb
Marking of wild animals and plants (diaspores)	Significance of livestock as vectors for passive dispersion	Rhoen, Swabian Alb

The abundance of nutritional resources during the pre-imaginal phase, that is, a window of perhaps only a few weeks, is decisive for population numbers in the following year. Until now, it has hardly been properly taken into account in nature conservation strategies that the survival of many species in Central Europe depends not only on the existence of structurally stable habitats and resources, but also on the 'on time' availability of these ephemeral factors.

For an analysis of the micro-level, there is a wide spectrum of established ecological field methods. However, it is only seldom that these allow for a direct causal connection with grazing effects. At the macro-level, too, there are targeted methods of evaluation which are available, though mainly providing only limited spatial resolutions or inadequate topicality (for example, remote data, communal statistics etc.). At the meso-level, there are glaring methodological deficits in area-wide, overall data collection and comparison evaluations. This is particularly the case for high resolution spatial data series. The use of substituting techniques, as they are currently used, in which data sets from the other two levels are transferred, are inadequate to answer the questions thrown up here, because of the meso-scale heterogeneity under study (point source data represent this insufficiently) and because of the spatial-temporal blurring of the macro-scale data.

A significant focal point of the work presented here was therefore the development of meso-scale methods of analysis with high spatial-temporal resolution. For this, various approaches were followed in parallel (Table 2.3). The perspectives and the limits of the methods applied are described in more detail in Chap. 4.

2.4
Economic Analyses

There cannot yet be a properly developed and reliable understanding of the economics of large-scale grazing, because this system is only practiced at scattered locations in Central Europe and under non-representative conditions. Even where it is practiced, information is often inadequate. In some of the keeping systems, which at least partially come close to the ideals researched in this book, even the operators themselves are not clear about the economic details. In extreme cases, which one can however see in practice, the animals were not purchased and paid for, but were delivered from some or other authority, or "were always there". Here, the required work is put in by personnel who also carry out other occupations. No account is kept over these inputs, and possibly as 'reward' for this, a product of the system, say, a slaughtered sheep, is distributed to the personnel. Even where economic issues are not so readily dismissed to this extent, one can still sense a considerable disinterest in these questions. Even long-existing model schemes and special research and development projects for extensive grazing have not given much attention to the economics (cf. Redecker et al. 2002); possible results from the practical projects on hand which operated parallel to this research work have not yet been published.

A main task of the economic studies in this book consists in bringing together the scattered knowledge which is available and transferring it to the specifics of large-scale grazing. The search for usable material impinges on three types of preliminary work:

- The most numerous by far concerns calculations for agricultural standard practices, such as cattle breeding. If this is also as extensively operated as dairy farming, then it is in fact not far removed from large-scale grazing which is in keeping with nature conservation. After the necessary processing of the data, however, such calculations are an important foundation for the subject at hand. In Sect. 8.1, the relevant literature will be considered and model calculations will be carried out in accordance with the required methodology applying to the farm business operation.
- There are several studies which gave been carried out on the effects of landscape care with grazing on old military training sites which were in the former German Democratic Republic, in particular by Prochnow and Schlauderer (2002). These areas are characterized by weak vegetation growth and forms of husbandry which are fairly undemanding with respect to production targets.
- For the first time, a comparative economic study has been carried out on more or less experimental and unconventional grazing projects, mainly with Heck cattle, which are farmed in different areas of Germany (Kaphengst et al. 2005). In spite of the difficulties referred to above concerning a systematically consistent consideration of economic factors, this study delivered significant results.
- Somewhat older studies concerning the economics of large-scale free-roaming and shepherded sheep farming systems (Tampe and Hampicke 1995) have added to the picture. The last three mentioned preliminary works will also be critically considered in Sect. 8.1. All in all, this provides a thoroughly robust picture of the economics of large-scale grazing systems.

In a further section (Sect. 8.2), a future scenario is developed for a hitherto agriculturally small-structured grassland region of the Rhoen in which certain agri-political direction changes have to be reckoned with. In this work, the perceptions of the local farming leaders are incorporated, as ascertained through a survey (Sect. 7.7). As well as politically determined developments (agricultural policy after 2013), a consideration is also made of current variants which appear utopian, such as the notion of a total liberalization within world market conditions. The chances for the establishment of large-scale grazing systems are essentially dependent on the agri-political environment.

Practical issues are tackled in Sect. 8.3 with a consideration of the hard realities of farming. The financial consequences are calculated for a large enterprise in the eastern part of the Rhoen which would occur following the transition from an already fairly extensive grazing system at present to an even more large-scale system in which stochastic effects could be expected. In this case, the already existing large-scale structure makes a transition of this type easier.

2.5
Working Hypotheses

For all investigations, the general assumption was that livestock can generate far greater ‘close-to-nature’ and differentiated spatial-temporal ecological effects than previously accepted if they are given the freedom to fully unfold the behavior pattern typical of their species. If this is correct, then large-scale systems with the associated behavior-determined freedom of choice would be a decisive criterion for the conservation value of pastureland. The influence of livestock would not then have an even effect within a short time, as is seen in the present-day with the usual small-area rotational grazing but would become differentiated with varying localized effects from the pressures of use as the livestock follow particular preferences. This should result in a clear habitat diversification and therefore provide for colonization opportunities for significantly more non-domesticated animal and plant species.

Specifically, the investigations are based on ten working hypotheses:

Hypothesis 1. The decisive factor for the achievement of a high level of biodiversity is the spatial-temporal heterogeneity of the livestock effects. It increases significantly depending on the size of the pasture, the type of grazing system and ultimately on the freedom of the animals themselves in satisfying their particular living needs. On large-scale systems, behavioral aspects of the wild ancestors are reactivated, such as social order and grooming behavior.

Hypothesis 2. On sufficiently large areas, grazing leads to a strengthening of the existing habitat diversity rather than a leveling of it, in contrast to effects from 'modern' systems of husbandry. Large-area livestock pastures are therefore more diverse than other farmed areas within the same landscape area.

Hypothesis 3. With livestock farming on large areas, the animals bring similar conservation benefits as wild animals and semi-wild domestic and 'bred-back' breeds. In addition, the logistical and economic integration in agricultural enterprises is more favorable. However, the effects of the individual livestock species show considerable differences.

Hypothesis 4. Some grassland ecosystems are therefore particularly species-rich because the 'historical' use continues to prevail. A more sophisticated understanding of the farming systems that were formerly used is therefore an important basis for the 'right' type of management for such areas.

Hypothesis 5. Transhumance and other shepherding systems have positive effects on the survival probability of grassland species, in that they transport dispersion entities and create a more favorable spatial-temporal habitat pattern at the agricultural level.

Hypothesis 6. While it is true that grazing animals make a significant contribution to the progress of vegetation development, they are not capable alone of keeping landscapes open in the long term. Parallel to this is the necessity that there should be either 'hard' natural 'disturbances' or additional anthropogenic interferences within the framework of so-called 'pasture management' or mowing.

Hypothesis 7. Compared with the current average situation, high biodiversity on pasture land can only be expected under very nutrient-poor conditions and a grazing pressure which completely exhausts the capacity of the particular area.

Hypothesis 8. Although relatively extensive agricultural grazing enterprise systems and especially suckler cow farming is known to be particularly loss-making and therefore in need of subsidy, there are possibilities for cost reductions so that large grazing systems could be seen as realistic and publicly financeable land use alternatives. Of course, this presupposes the existence of corresponding agricultural structural conditions, which are more likely to be found in the federal states of the former German Democratic Republic.

Hypothesis 9. There is no categorical contradiction between traditional agricultural grassland usage and large-scale grazing; in fact, there is a continuum of graduated intensity. Elements of intensive land use such as dairy farming could be very suitable partners of large-scale grazing, as in the case of the raising of young cattle.

Hypothesis 10. Each type of land use in Central Europe is enmeshed in a system of political intentions, requirements and obstacles. The form of this background situation has greater consequence even than many of the internal economic problems affecting the enterprise. Large-scale grazing will find its place when the politicians set the course in its favor. The most important thing here is the provision of specific financial rewards for agri-ecological achievements.

2.6
Focal Points in this Book

The following key areas for consideration arise from the working hypotheses:

Chapter 3 describes the area of investigation in more detail. Chapter 4 focuses exclusively on the further development of relevant survey and analysis methods on terrains, in which a particular emphasis will be placed on meso-scale and high frequency methods and the analysis of livestock behavior.

Chapter 5 deals with findings at the micro-level, Chap. 6 at the meso-level and Chap. 7 at the macro-level, including economic case studies. Chapter 8 summarizes the findings with a series of contributions, relates them to accepted knowledge and derives from this practical recommendations for action.

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Chapter 3

The Areas of Investigation

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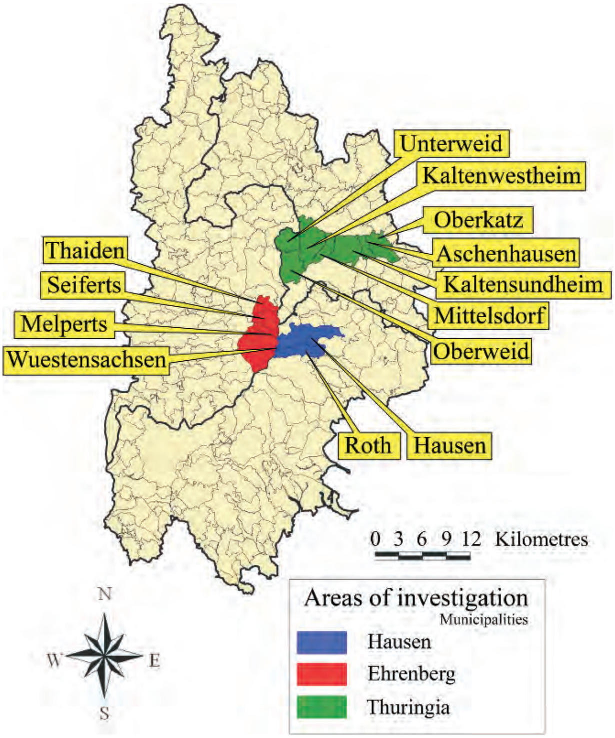
3.1

The Rhoen

The Rhoen is a low mountain range in which the highest point is just short of 1 000 m a.s.l. – the Wasserkuppe at 950 m. It is part of the late Germanic volcanic formations. Consequently, the center consists predominantly of basalt soils with limestone and sandy soils occurring at the edges. The level of precipitation can exceed 1 000 mm yr^{-1} but generally remains below this figure. The area of the Rhoen belongs to three federal states – Hesse, Bavaria and Thuringia. Since 1991, the Rhoen has been recognized by UNESCO as a biosphere reserve (Deutsches MAB-Nationalkomitee 2004), which is one of the reasons why the area was chosen for investigation (see Seville Strategy for the development of sustainable, transferable land use forms) (Fig. 3.1).

Fig. 3.1.
Location of the Rhoen investigation areas



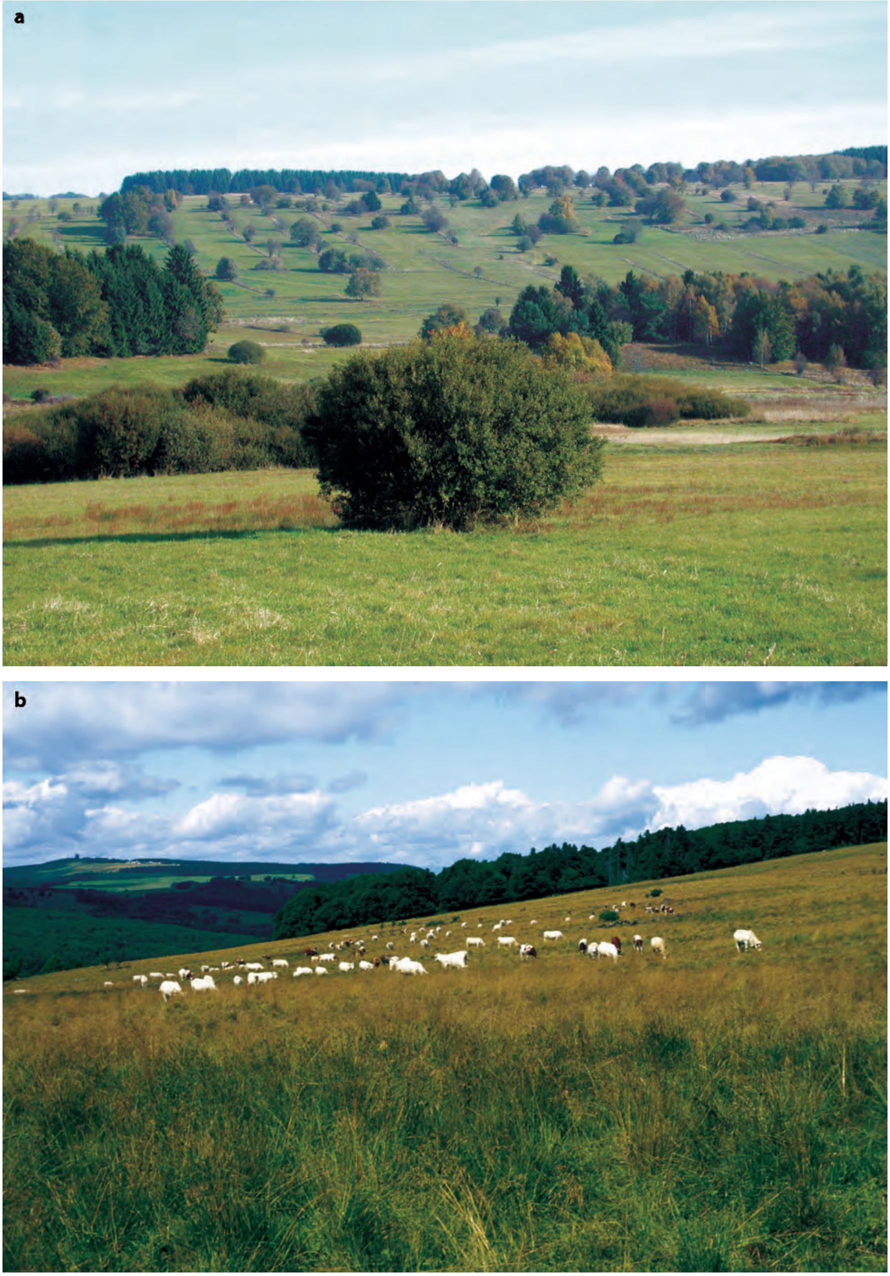


Fig. 3.2. **a** High Rhoen landscape (Bavaria): the mat-grass plain has been maintained in this condition for decades through nature conservation management; **b** cattle grazing on the valley side, here at Upper Ulstertal (Hesse) (photos: H. Plachter)

With regard to the history of land use there, the relatively harsh high plain, which is largely unsettled, has been used predominantly as cut grassland (mat-grass) with post-grazing. Extended communal livestock grazing took place mainly on the lower slope edges and as far as the surrounding valleys where the communities were located. These grazed slopes used for cooperative grazing systems have remained until today in surprisingly good structural condition, although now they are used almost without exception for rotational paddock grazing (Fig. 3.2). Until a few decades ago, the landscape of the Rhoen was still largely characterized by grazing. Arable farming played hardly any role at all (Fig. 3.3). The concept for the future development of the Rhoen is oriented to the idea of the 'land of the far horizons'. The objective here is the preservation of wide stretches of sparsely wooded, open landscape and where necessary, to redevelop this following the extensive afforestation of the 1940s (Grebe and Bauernschmitt 1994).

Today in large parts of the Rhoen, agricultural activity is barely profitable and many enterprises are able to survive only with the help of additional incomes from tourism. However, the agricultural structure is clearly different in the three federal states. In Hesse, there are mainly small to medium sized mixed enterprises. The Bavarian part (High Rhoen) is largely managed in a comprehensive system of nature conservation landscape care through surrounding farms, without allowing production goals to play too great a role. In the Thuringian part, the former 'LPG' cooperatives, now in the form of very large (up to almost 3 000 ha farm land) private agricultural enterprises, have in part continued to operate.

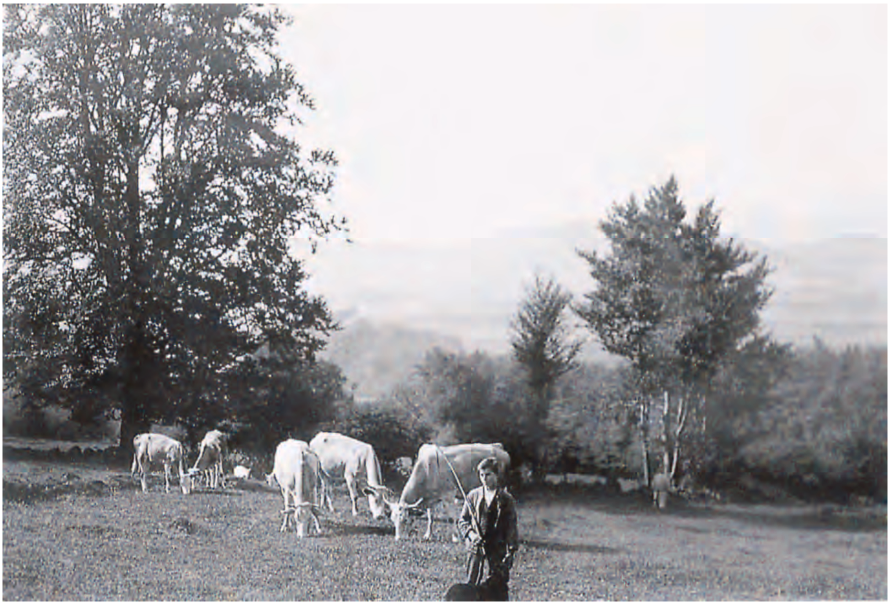


Fig. 3.3. The Rhoen at Gersfeld as a 'pastoral landscape' – a photograph of shepherded cattle from the year 1927 (from Beinlich and Manderbach 1995)

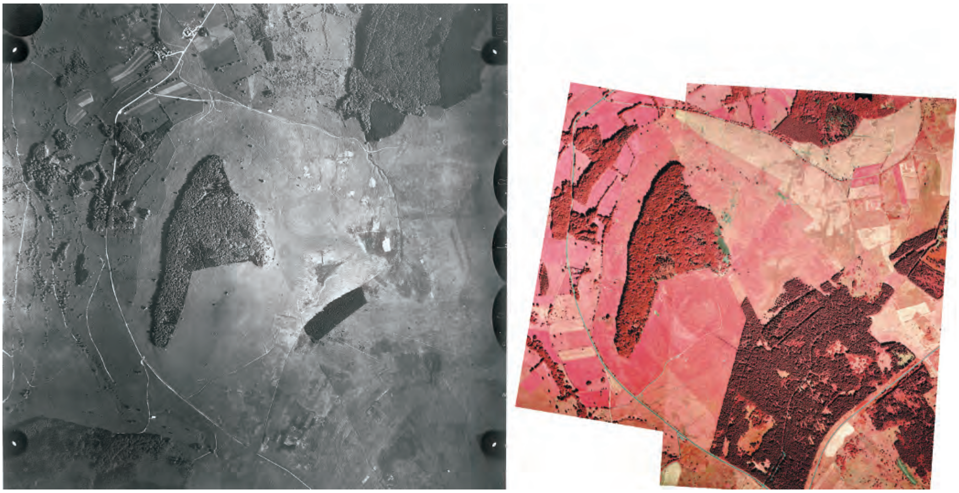


Fig. 3.4. Steinkopf in the upper Ulstertal (Hessian Rhoen): large-scale cooperative grazing; the situation in **a** 1937 and **b** 2001

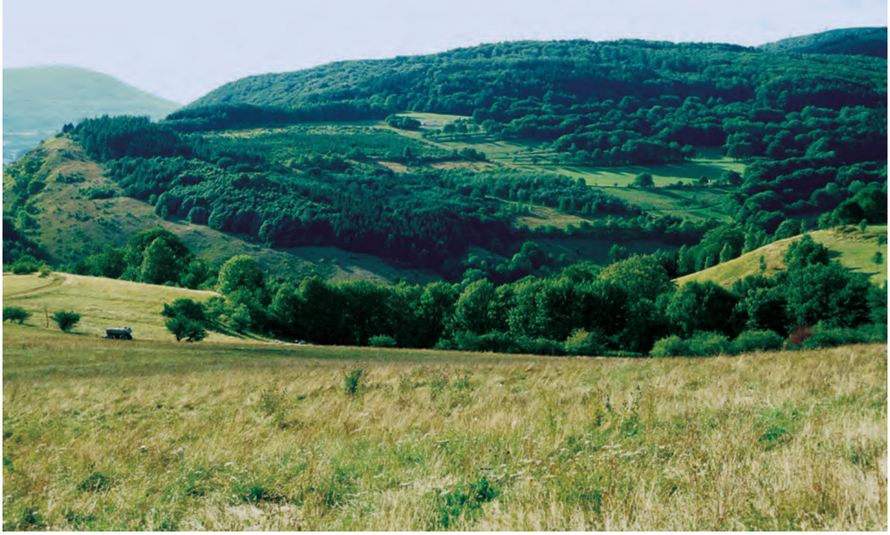


Fig. 3.5. Thick scrub growth over parts of the 'grazing belt' at Unterweid, Thuringian Rhoen. In the center, one of the experimental set stocking pastures for young livestock, in the foreground and rear left, stationary shepherded sheep grazing (photo: H. Plachter)

The investigation areas lie in the upper part of the Hessian Ulstertal and in the Thuringian Rhoen, on farm land belonging to the 'Agrarhöfe Kaltensundheim GmbH' (Fig. 3.1). An area which included the upper Ulstertal and also parts of the high Rhoen area was also included for the implementation of scenarios for future development options (see Sect. 8.2).

On the east side of the Ulstertal and stretching to the high Rhoen, there are grassland belts of the former cooperative grazing land which remains structurally unaltered. However, the form of farming has radically changed in the last four decades. Roaming sheep flocks occupy only a very limited area of the land. Most of the area is divided up with fenced paddocks which are used for plot grazing for the raising of bullocks and heifers. Residual forms of the old grazing system are still practiced, to the extent that the herds are not all from any one particular farm. Cattle brought in from other regions are playing an increasing role (Fig. 3.4).

In the Thuringian investigation area to the west of the village of Kaltensundheim, the former use of the landscape also survives in parts. On the steep valley sides, there are

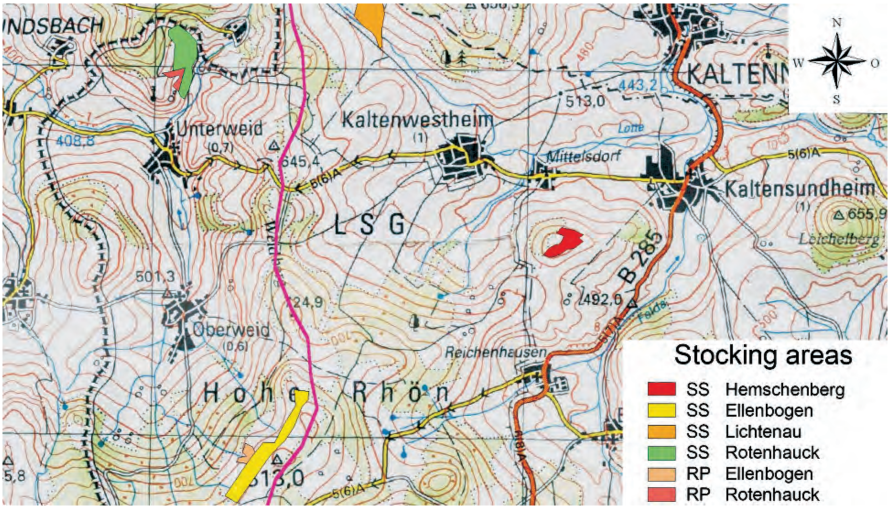


Fig. 3.6. Location of the experimental set stocking and rotational pasture areas in the Thuringian Rhoen

Table 3.1. Experimental use designs in the six investigation areas in 2001 and 2002. Stocking density here refers to the actual number of livestock units (LSU) per hectare over the grazing period

Area	Rotenhauck 1	Rotenhauck 2	Ellenbogen 1	Ellenbogen 2	Hermschenberg
Breed	Holstein Friesian	Holstein Friesian	Holstein Friesian	Holstein Friesian	Simmental
Age	Young cattle	Young cattle	Young cattle	Young cattle	Suckler cows
Type of use	Set stocking	Rotational pasture	Set stocking	Rotational pasture	Set stocking
Size (ha)	2001: 20 2002: 20	2001: 5 2002: 6	2001: 37 2002: 37	2001: 7 2002: 7	2001: 25 2002: 25
Stocking density (LSU ha^{-1})	2001: 0.8 2002: 0.8	2001: 7 2002: 6	2001: 1.8 2002: 1.8	2001: 6 2002: 6	2001: 0.7 2002: 0.7
Grazing period	May–Sept.	3 × 5–10 d (June–Sept.)	May–Sept.	3 × 5–10 d (June–Sept.)	May–October

extended grassland areas which are partly used for sheep grazing (stationary shepherding) but most of the land is given over to cattle grazing on plots (Fig. 3.5). Here in 2001, four relatively large-scale experimental set stocking (continuous grazing) areas for young cattle and suckling cow husbandry could be established, with close cooperation with the agricultural enterprises. The results were compared with two neighboring rotational grazing areas operating with what is today a normal grazing management system (Fig. 3.6). The size of the experimental set stocking area changed over the three investigation years for various reasons. Figure 3.1 shows the conditions in the years 2001 and 2002.

3.2
The South Black Forest

The area of investigation lies in the catchment of the upper Wiese Valley in the main section of the nature park 'South Black Forest' and is part of a low mountain range of around 8 000 km^2 in the south-west of Germany.

The pastures within the investigation area are situated between 600–1 200 m above sea level. The Black Forest is characterized by pronounced climatic differences. Whereas the long-term average for precipitation in the Rhine region is 600–800 mm per year, the figure for the investigation area is up to 1 800 mm yr^{-1}. On the grazing areas which were studied, the characteristic plant communities are characterized by fescue grasslands and broom growths (Festuco-Genistetum sagittalis). Typical, mainly thermophilic plant species include broom (*Genistella sagittalis*), silver thistle (*Carlina acaulis*), heath violet (*Viola canina*), arnica (*Arnica montana*), wild thyme (*Thymus pulegioides*) and mouseear hawkweed (*Hieracium pilosella*). The predominant grasses are red fescue (*Festuca rubra*) and common bentgrass (*Agrostis capillaris*). On areas of nutrient-

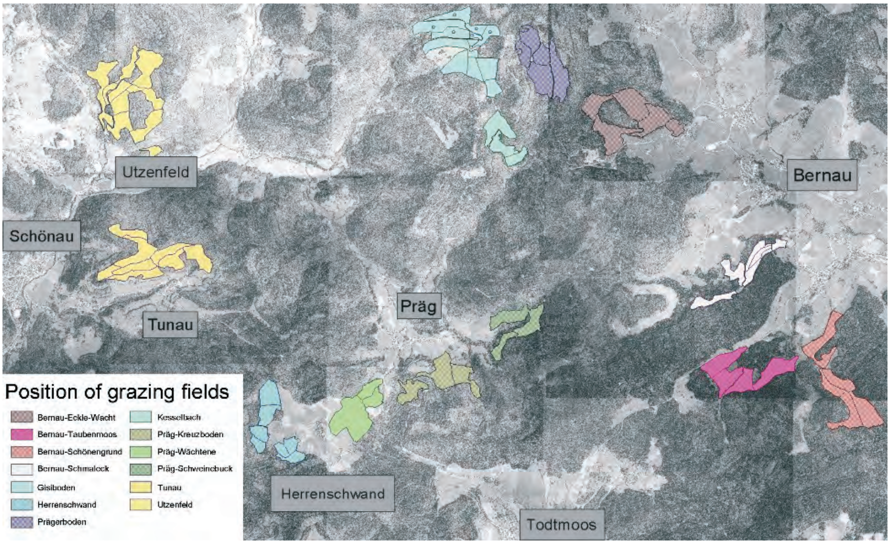


Fig. 3.7. South Black Forest. Distribution of the investigated seven 'grazing fields'. The grazing areas of the Präg Glacier Valley are shown in different colors

enriched soil, mainly in lower sections, there are open pastures (Cynosurion) with common dandelion (*Taraxacum officinale*), broad-leaved dock (*Rumex obtusifolius*) and orchard grass (*Dactylis glomerata*) (Figs. 3.7, 3.8).

Since the time of settlements in the Early Middle Ages, pastoral farming has been carried out in the Black Forest. In this system of land use, a communal form of grazing use became established quite early and remained largely unchanged over centuries (Beinlich and Manderbach 1995). This communal grazing use goes back to the earliest times of livestock farming in the Black Forest and is based on the 'common grazings' of the Middle Ages, under early Germanic legal regulation (Pohle 1986). Until today, various types of these communal grazing systems can be differentiated (Eggers 1957): (1) cooperative grazing (all who are entitled to graze have decision-making powers), (2) commons grazing (community council makes decisions), (3) collective grazing (private rights), (4) private community grazing (formerly cooperatives, then private rights). With currently up to about 10 000 ha of community grazing, the South Black Forest is the only region in Central Europe in which this organization form has so extensively survived (Luick 1997). In some aspects, however, the conditions of use have changed drastically. Dairy farming has declined greatly and the pastures are today predominantly stocked with young cattle. Older, locally-adapted cattle breeds have been replaced with 'modern' breeds. The pastures are 'improved' with slurry and sometimes with mineral fertilizers. The type of pastureland management has clearly changed.

Also in this investigation area, former cooperative grazing systems have survived structurally until today (Eggers 1957; Kersting 1991; Luick 1997; Reif and Katzmeier 1986). Just as in the Rhoen, however, the whole of the Black Forest has seen a major

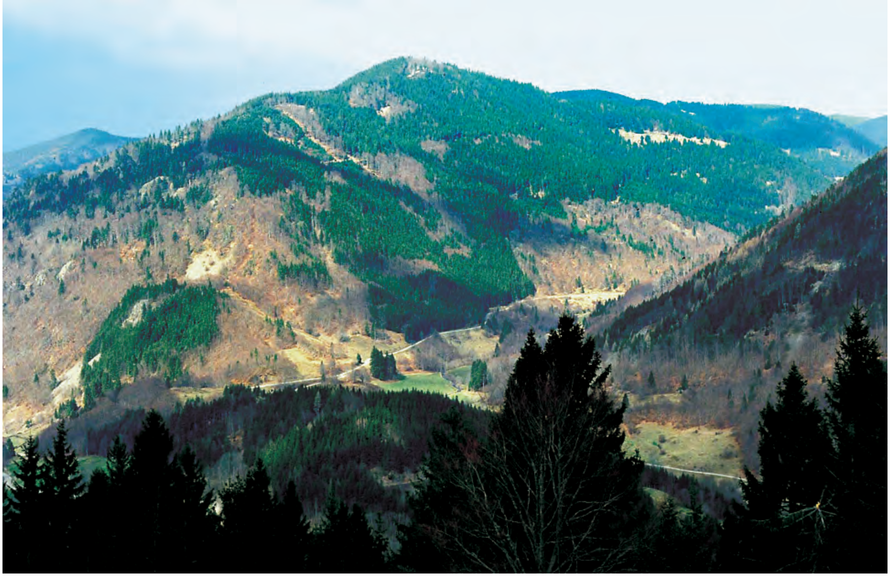


Fig. 3.8. Present-day grazing land for young livestock as agri-structural residue from former communal 'grazing fields' in the Präg Glacier Valley. One can see the high level of tree cover, particularly the relatively recent afforestation on grassland areas in the top left of the picture (photo: H. Plachter)

change in the type of land use: land which was once stocked with dairy cows is now used for plot grazing with young cattle – although still with set stocking. Several paddocks traditionally group together to form so-called ‘grazing fields’. A total of thirteen such grazing fields in the region, made up of 71 paddocks, were comparatively analyzed. The focus here was on the pastures in the Präg Glacier Valley.

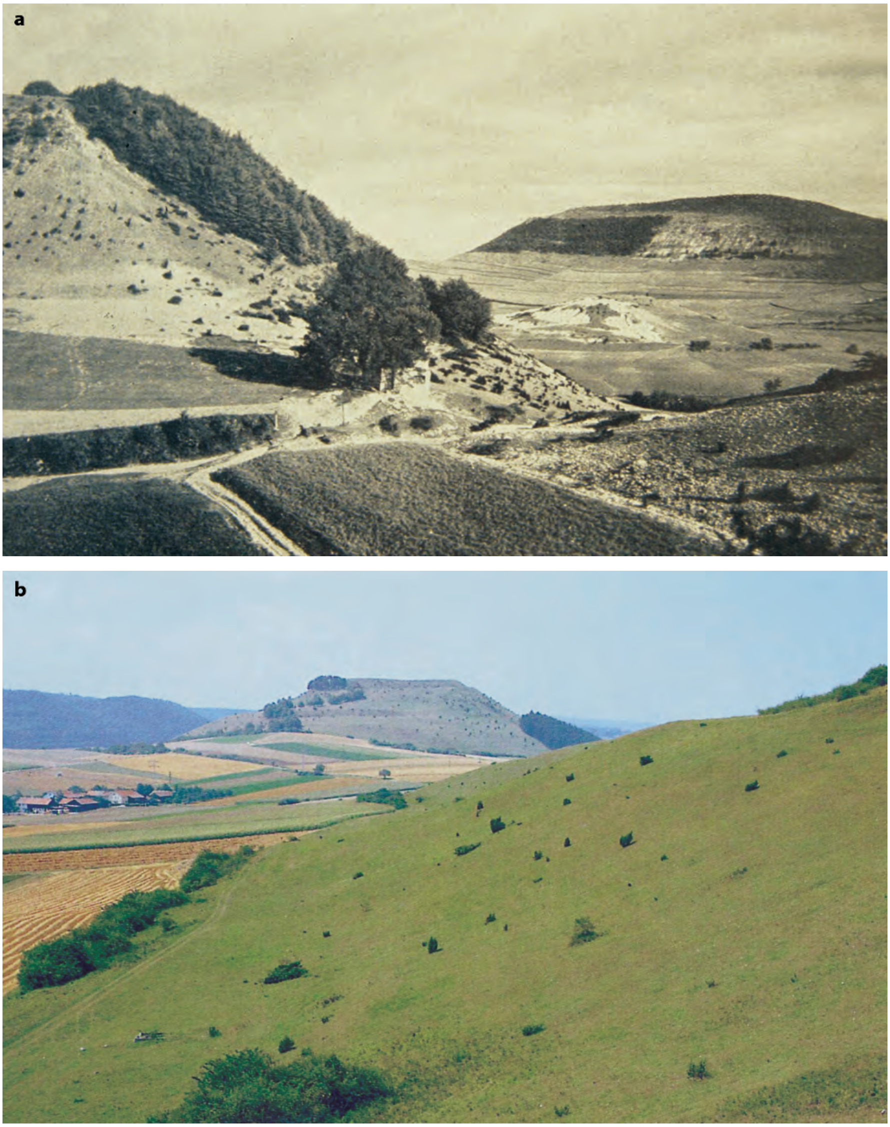


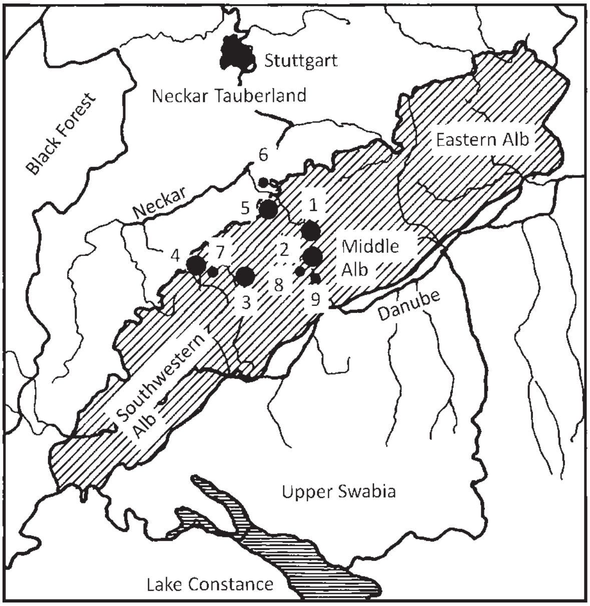
Fig. 3.9. a Swabian Alb landscape around 1930. Notice the extensive rough pastures on the left side of the picture (source: Schwenkel Archive, LfU Bad.-Württ.); **b** Blasenberg/Ipf, Baden-Württemberg; landscape shaped by grazing, which largely accords with the historical situation (from Beinlich 1995)

3.3
Middle Swabian Alb

Even today, there are still 17 000–20 000 ha of rough grasslands (predominantly limestone grasslands; Plachter and Schmidt 1995) in the Swabian Alb, a low mountain range built up of Mesozoic limestone in south-west Germany, making it the most important continuous area of this formation type. Over the course of history, the area which is now neglected grassland was used in various ways – sometimes as arable land as part of a crop-grass rotational system, sometimes as meadowland. However, the dominating use was always pasturing with livestock. Cattle grazing may have played a considerable role locally, but the grazing of roaming sheep flocks was of much greater significance. This type of use was part of a transhumance system and took place because of the geographical location among places with favorable climate conditions such as the rift of the Upper Rhine River and the Lake Constance Basin. Over the centuries, the Swabian Alb region was a preferred summer grazing area for roaming sheep flocks which were taken to the neighboring milder regions in winter. Even today, this continues to shape the structure of the landscape (Fig. 3.9).

As in other parts of Europe, sheep farming has no longer been profitable for decades in Germany, not least because of the internationalization of the markets. Above all, the personnel costs and the necessary investment are in no way proportional to the expected yields for roaming sheep systems (Hampicke and Tampe 1995).

The land use pressure from the effects of grazing on the rough limestone pastures of the Swabian Alb has significantly declined in the last few decades, with the



1 Sheepwalks near Muensingen
2 Great Lauter Valley near Buttenhausen
3 Trochtelfingen Heath
4 Sheepwalks between Beuron and Jungingen
5 Grassland at Pfullingen Mountain

Fig. 3.10. Investigation areas in the middle Swabian Alb south of Stuttgart (from Plachter and Schmidt 1995, modified)

consequence that more and more efforts are required to fight the growth of woody vegetation (Beinlich and Plachter 1995). One alternative could be to allow at least part of the neglected grassland to undergo succession without further intervention (Beinlich et al. 1995). For particular cases, this may be sensible, but the loss of an ecosystem type of such European importance is generally of greater concern. It was therefore necessary to analyze the possibility of an efficient and cost-reduced management system in a landscape area of the middle Swabian Alb (Fig. 3.10) (cf. Beinlich and Plachter 1995).

3.4
Central Georgia

Georgia is located south of the central ridge of the Greater Caucasus Mountains (Fig. 3.11). Within a very wide climate spectrum, and mainly in the Lesser Caucasus Mountains, there are regions between 800–1 200 m which have a similar local climate and also a similar landscape structure to the Central European low mountain ranges (Fig. 3.12). The country is oriented towards Europe both culturally and with respect to the social structures. Since time immemorial, livestock pasturing was common throughout the land, partly with transhumance systems in which the summer and winter grazing areas lay hundreds of kilometers apart. The breakdown of the Soviet economy and the attainment of independence for the country was followed by a radical privatization of agriculture, with the result that now there is a high number of very small family farms (State Department for Statistics of Georgia 1999; UNDP 1996). This caused a return to an almost archaic system of bartering and production conditions based on local marketing. Except for wine production, there is an almost complete absence of the use of mineral fertilizers and plant protection chemicals, and agricultural machinery has also become less and less available (cf. Didebulidze and Plachter 2002). The most basic aspects of livestock farming in particular bear a striking similarity to systems practiced in Central Europe in historical times. At present, practically the whole land is subject to a more or less strong pressure from pastoralism, and woodland grazing is widespread (Fig. 3.13). The grazed river flood plains have strong structural similarities to representations from Central Europe at the start of the nineteenth century. Cattle and sheep are mainly kept in shepherded communal flocks (Bontjer and Plachter 2002), and pigs range freely or are herded into more favorable woodland areas.

For meso-scale investigations into the ecological effects of shepherded cattle grazing and the systems of husbandry, a clearly delineated grazing area about 20 km north of Tbilisi was chosen (Fig. 3.14) – mainly for logistical reasons and in the face of the otherwise rather chaotic conditions (see Fig. 3.11). It comprises the pastures of an isolated butte mountain at the southern border of the Greater Caucasus which is used by two neighboring communities for cattle grazing. The local climate is continental semi-arid and the species populations contain a mix of Central European, Mediterranean and central Asian elements. The pastures consist of a mosaic of sward ecosystems of varying trophic grades, interspersed with several woodlands. The prevailing vegetation is shibliak, which is structurally very similar to the bushy neglected grasslands of Central Europe.

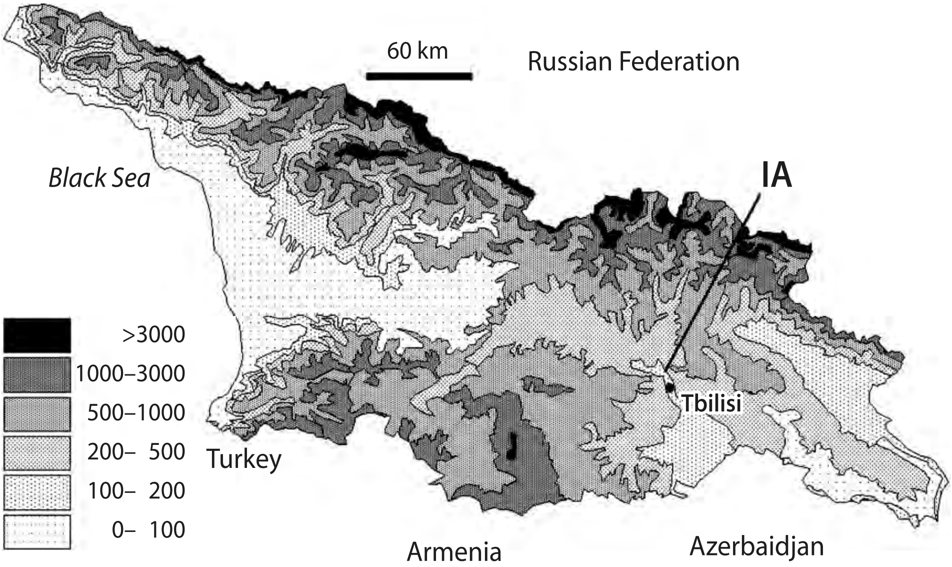


Fig. 3.11. The location of the mesoscale investigation area (IA) in Georgia north of the capital Tbilisi

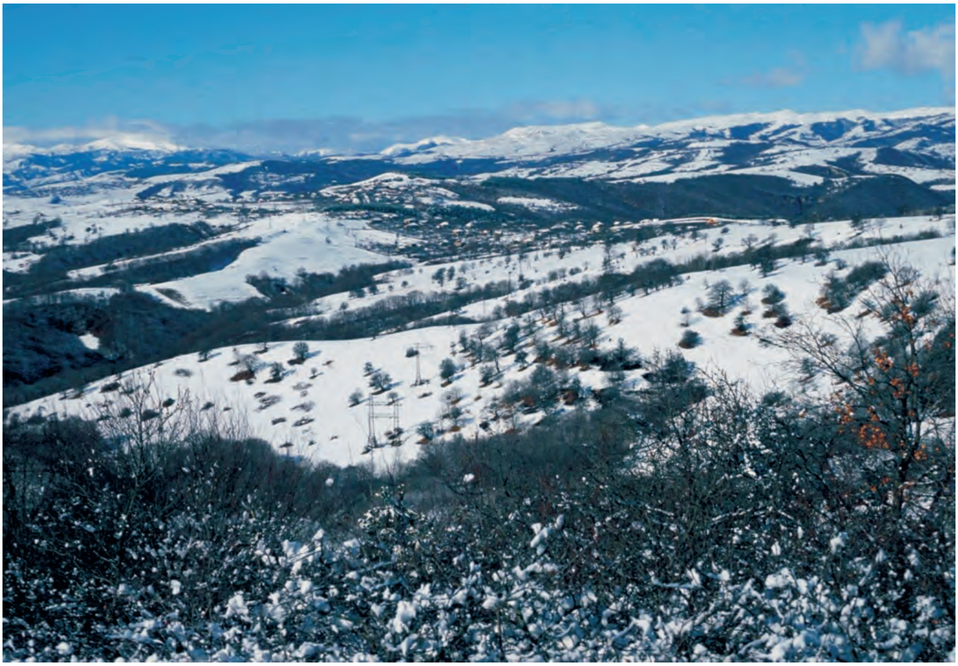


Fig. 3.12. The landscape of the Lesser Caucasus at Orbeti, west of Tbilisi, at about 1000 m a.s.l. (photo: H. Plachter)

a
b
c
d

◀ **Fig. 3.13.**
Livestock grazing is found throughout Georgia: **a** post-grazing of a cereal field in south Georgia with sheep; **b** road-side verges are important grazing areas (north of Tbilisi); **c** extensive winter grazing (cattle) in a steppes area south of Tbilisi (David Gareji, winter aspect); **d** woodland clearing as a result of firewood collection and grazing, Surami Mountains (photos: **a–c** H. Plachter, **d** P. A. Schmidt)

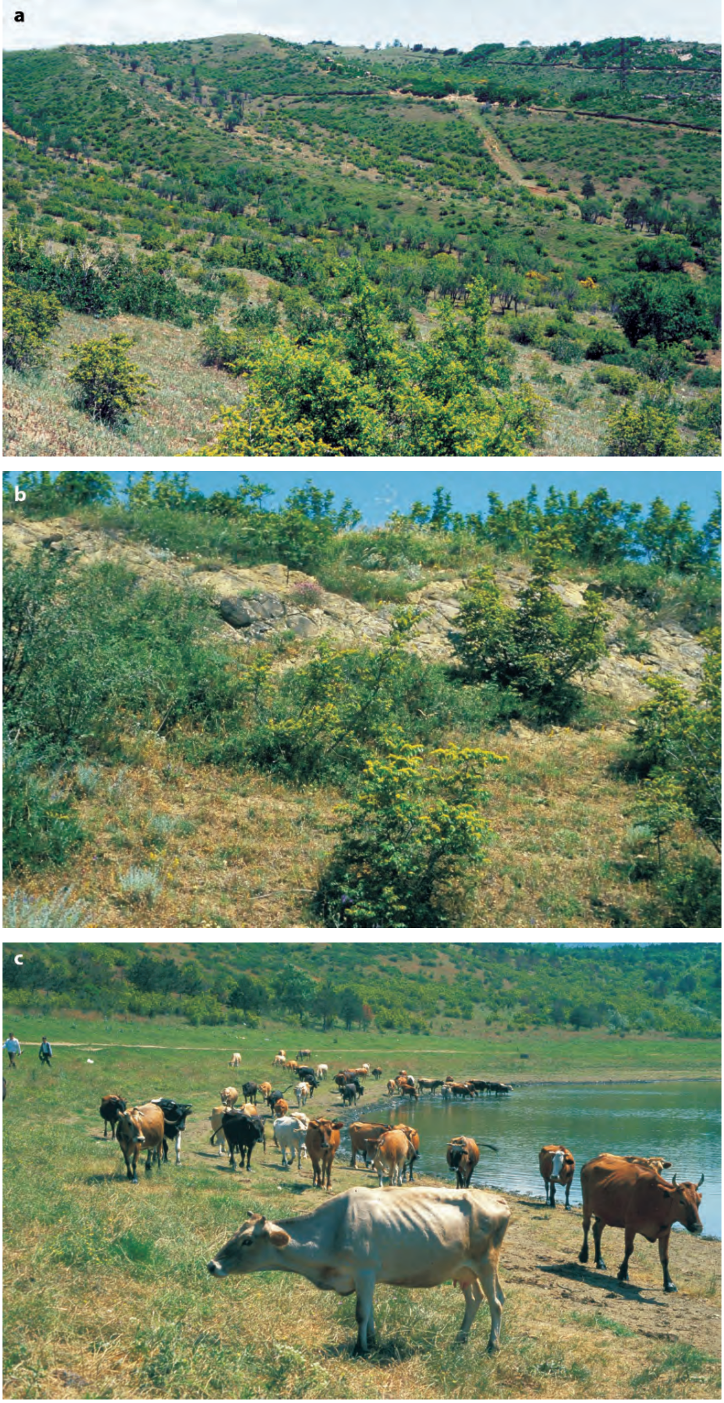


Fig. 3.14. ▶
Investigation area on a butte mountain to the north of Tbilisi (Mzkheta): **a** cattle grazing on shibliak; **b** Shibliak with blooming Jerusalem Thorn (*Paliurus spina-christi*) and mugwort (*Artemisia* sp.); **c** one of the two herded cattle flocks (photos: H. Plachter)

3.5
Western Ukraine

Ukraine is bordered by the mountain range of the Forest Carpathians to the west. This low mountain range rises to 2 000 m south-west of the town of Lviv (formerly Lemberg). The bedrock consists of limestone, but also of acidic substrates at the eastern slopes of the mountains, from which the upper waters of the Dnister flow (Fig. 3.15). The climate is moderate continental, with values comparable to the western part of Central Europe, and the dominating natural vegetation unit is the red beech forest (Fagion).

The Soviet socialization of land use did not have a great impact on these peripheral regions. Older, more communal forms of organized land use have survived, and with them, a landscape structure which was probably typical for most of the mountainous districts of Central Europe a hundred years ago (Fig. 3.16).

The breakdown of the Soviet economy had similar consequences here as in the case of Georgia, although the return to a system of subsistence farming was not so drastic. The conventional peasant farming, still in the memory of the local populations, was taken up again. Here also, subsistence farming is in the foreground, although practiced on a higher technical and logistical level. There are close connections to the metropolis of Lviv and increasingly, to the west European markets (the borders with Slovakia and Poland are only a few kilometers distant).

The objective of a BMBF research project (see Horban et al. 2000) was the transfer of Central European conservation and development strategies to the regions of the upper Dnister. A sub-project was concerned also with the analysis of livestock grazing (Plachter and Niemeier 1997). The focus of the investigation was on the community of Busovesko, located in a part of the upper valley of the Dnister, in which the old use structures of extensive grazing belts are still well preserved along the valley sides (cf. Tsaryk and Tsaryk 2002). A further advantage was the availability of detailed community archives on land uses, going back to the end of the nineteenth century.

Fig. 3.15.
Location of the East Carpathians in western Ukraine and the Busovesko community on the upper Dnister

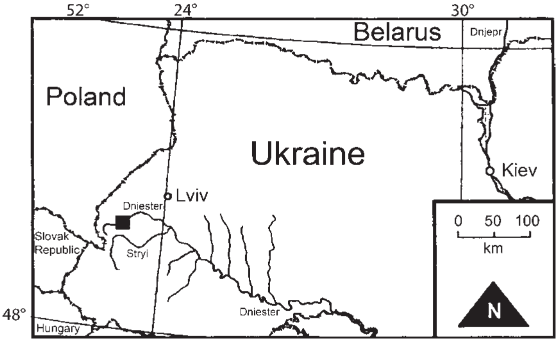


Fig. 3.16. ▶
a Extensive cattle grazing in the (treeless!) plain of the middle Dnister at Stari-Frankivsk (to get an idea of the size, see grazing cattle left of the center); **b** meadows for winter feed at about 1 000 m a.s.l. on the upper Opir, a tributary of the Dnister; **c** Busovesko community: mixed use in the valley, grazing belts along the valley sides; **d** section of a cattle pasture on the valley side, used by the Busovesko community (photos: **a, b, d** H. Plachter, **c** R. Satzger)

a
b
c
d

3.6
South Oeland

The island of Oeland to the south of Sweden seems at first sight to have very little in common with the Central European low mountain ranges. The island rises above the sea by only a few tens of meters (Fig. 3.17). However, the similarities are far greater than may seem at first sight. In the southern part of the island, a solid layer of limestone overlies a softer stratum of Paleozoic shale, forming a seam a few kilometers wide which extends to the coast of the Baltic Sea. This limestone layer has been worn smooth by ice-age activity and is covered with a mosaic of silicaceous ground moraine deposits. This situation has determined the natural and cultural development of the island over thousands of years.

After the island had risen from the Baltic Sea in the Holocene period, a form of vegetation known as 'Alvar' – a semi-steppe type – developed on very shallow soils in which trees could only gain a hold in cracks in the limestone layer and on ground moraine outcrops. The climate is very unusual for a maritime island, receiving relatively low rainfall (Johansson and Larsson 1992; Königsson 1968) because of its situation in the rain shadow of Scandinavia. It is subject to 'hard' environmental effects such as frequent frosts (Oeland is the southern-most part of Europe which has recent polygon soils), the appearance in springtime of temporary, shallow lakes on the still-frozen ground, and frequent strong winds. The vegetation at present is consequently much more that of a low mountain range landscape than a flat marine island. On the sparsely grown Alvar areas, the dominant plants are woody bushes and dwarf varieties (*Prunus spinosa*, *Juniperus*, *Potentilla fruticosa*, *Helianthemum oelandicum*), varieties of basiphil sparse grasses and Central European steppe elements (*Artemisia*; among other species, the pink-winged grasshopper *Bryodema tuberculata* is found) (Fig. 3.18).

Fig. 3.17.
Location of the island Oeland, Sweden and the area of the Alvar

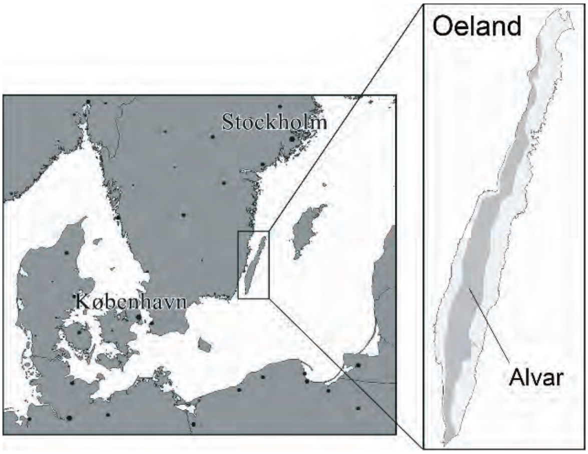
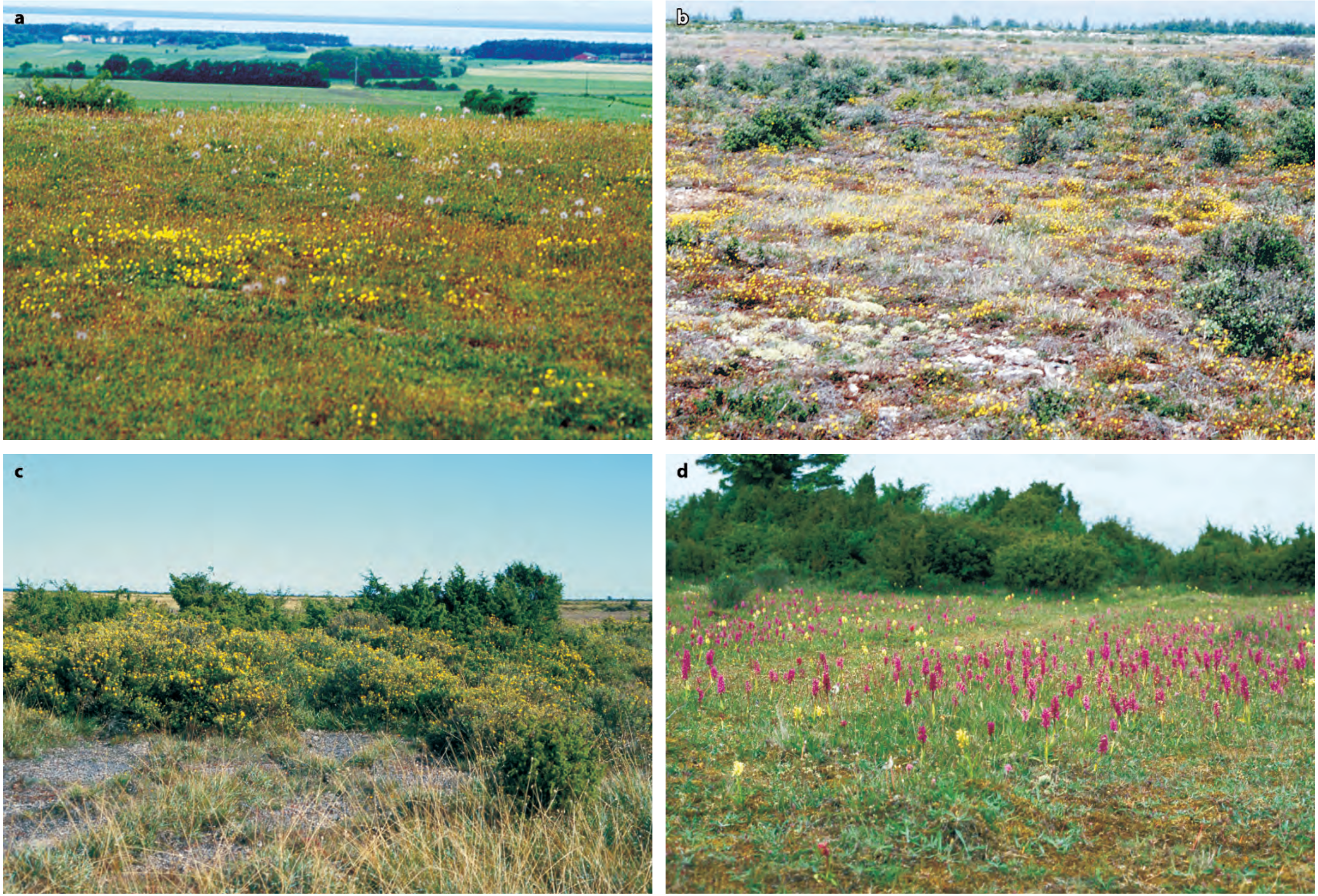


Fig. 3.18. ▶
a The view from the Alvar towards the arable land near the coast; **b** pastures on the Alvar; **c** increasing bush growth with *Potentilla fruticosa* because of the absence of current use; **d** ground moraine area rich with orchids on a cattle pasture of the Alvar (photos: **a, c, d** H. Plachter, **b** U. Hampicke)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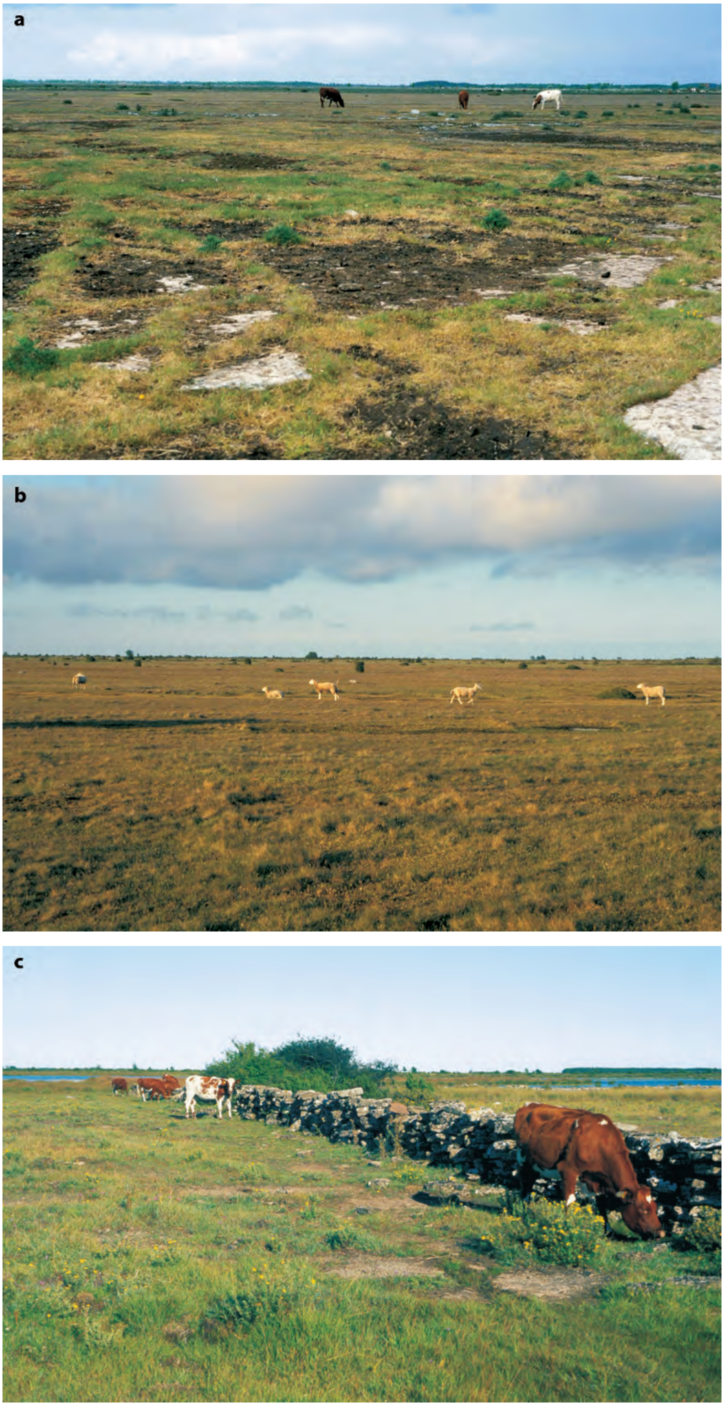

Fig. 3.19. Livestock grazing on the Oeland Alvar **a** continuous cattle grazing; **b** continuous sheep grazing; **c** movement of cattle along the 200 year-old stone walls forming the boundaries of communal pastures (photos: H. Plachter)

Very shortly after the island rose from the sea, it was settled by humans. The Alvar is the result of an interaction between wild and domesticated herbivores and the development of the vegetation which has continued to the present (Rosén 1982; Titlyanova et al. 1988).

The south of the island still possesses a landscape structure which is at least medieval and in significant aspects, neolithic. This was one of the reasons why this part of the island was declared a World Heritage Site of UNESCO in 1999. The communities have existed for thousands of years arranged along a line like a string of pearls on the outer edge of the Alvar, with crop production land on the lower-lying shale and pro-rata pastures on the Alvar. After the cooperative phase of the Viking period, the Alvar then became a royal domain until 1817, when it was divided up with stone walls to form communal grazing areas. 'Communal pastures' were created with areas measuring several square kilometers, which were grazed in accordance with yearly husbandry plans (Fig. 3.19). This division of use has continued until today. South Oeland is therefore one of the few places in Central Europe in which even today under EU agricultural schemes, large-scale grazing with cattle and sheep in 'normal' agricultural enterprises is successfully practiced. This is striking because in other parts of the EU under such forms of use, particularly on nutrient-poor soils, the return is agreed. It is clearly possible again here because of the current EU financial assistance (see EU regulations 2078 and 1257).

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Chapter 4

Method Development

4.1

The Recording and Analysis at Different Scales of High-Resolution Aerial Photograph Series for the Investigation of Changes to the Structure of Vegetation on Pastures

Manuel Conradi †

4.1.1

Introduction

Large livestock pastures are subject to non-linear, stochastic changes in space and time. The livestock continuously change the structures of the pastures by affecting or setting in motion ecological processes there through the various manifestations of their activities. The resulting effects are subject to an extremely high spatial and temporal variance. Under the conditions corresponding to a freedom of choice available through the size of the area, a pattern of habitats arises induced by the livestock which can be relatively stable over time for some areas (for example, broken ground near watering places) but in other places, may be subject to a high spatial-temporal dynamic (for example, vegetation height and flower density dependent on the grazing behavior). These types of structural elements are frequently very small, irregularly distributed (often clumped together), and 'ephemeral'. Whether they are essential or not for wild animal and plant species (such as pioneer plants) depends on a combination of frequency, spatial distribution (distances) and temporal availability.

Many studies, particularly in the 1990s, showed that habitat heterogeneity is associated with an increased biodiversity (Benton et al. 2003) and can therefore serve the targets of nature conservation. It remains largely unclear as to how and on which spatial level such a heterogeneity can be measured and how ephemeral habitats can be classified which may exist at a site for perhaps only a few days but are permanently available in the overall picture of the ecosystem. This is above all a problem of missing methods of analysis. The probability of 'hitting' small-scale and locally occurring habitats with randomly distributed sampling points is relatively small. If in addition, the mapping of the spatial dynamic over the course of a year is required, the methods available up to now fail completely.

One solution is offered by the use of aerial photos which map out structural patterns over an area, can be repeated in relatively short time periods (Turner et al. 2003) and are also able to provide multi-temporal and high-resolution results (Hudak and Wessman 1998; Kadmon and Harari-Kremer 1999). With regard to the suitability of such procedures, however, the relevant scale level(s) plays a decisive role (Blaschke and Petch 1999; Riitters et al. 1996; Urban et al. 1987; Wiens 1989). In the case under consideration on the assessment of individual pastures or complexes of pastures using an area-wide structural analysis, and if necessary, also using time series (phenological and behavior-affected changes over a year), the problem concerns the meso-scale level.

For meso-scale analysis requirements, however, there are narrow limits set on the customary recording and evaluation procedures because of the resolution and information content. The objective of the following method study was therefore to be able to exploit the basic advantages of these investigation approaches better than was previously done, for the evaluation of livestock grazing – on the one hand through improvement of the evaluation approaches with purchasable aerial photographs and on the other hand through spatially adapted recording methods. For this purpose, various recording techniques and image processing procedures were selected according to their suitability for the task, and suitable parameters to describe the structure were generated. The focus here was on the development of optimal methods for area-wide, spatially explicit and detailed recording of changes to vegetation structures.

4.1.2
Investigation Areas

The investigated areas lie on the eastern slopes of the Ulster Valley, in the Hessian part of the Rhoen Biosphere Reserve. There were previously four dairy herds here belonging to the villages of Wüstensachsen, Melperts, Seiferts and Thaiden of the current Ehrenberg municipality (see Chap. 3).

Today, the pastures are sub-divided into 35 paddocks. Five of these are used in specific ways, for example, as drinking paddocks where several other paddocks have access within the relevant grazing periods, that is, at separate times. The rest of the 30 paddocks, with areas between 3.1 and 29.4 ha, were included in the study. The total area of the pastures amounted to 315 ha. 8 of the 30 paddocks, referred to as focus paddocks in the following sections, were investigated in detail (Fig. 4.1).

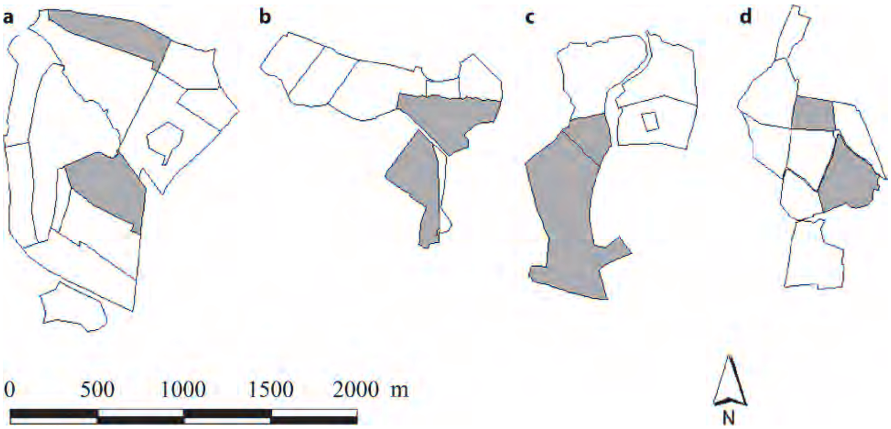


Fig. 4.1. Sub-divisions of the rotational grazing system in paddocks; the focus paddocks are shown here gray. **a** Wüstensachsen; **b** Melperts; **c** Seiferts; **d** Thaiden. The rotational grazing pastures emerged from unfenced cooperative grazing pastures

4.1.3
Method Screening

The results of screening and outdoor pre-trials (mapping structure with 100 m^2 plots) indicated that only repeated aerial photographs would be able to meet the demands of the data quality requirements and temporal practicability. Four different methods of becoming airborne were tested during the screening, to assess their general suitability (coverage, resolution, time required and costs) with respect to the given tasks.

1. Captive balloon
2. Captive kite
3. Remote-controlled model helicopter
4. Ultralight aircraft

A captive balloon consists of a carrier balloon which is filled with a light gas (usually helium). The camera is attached to a rig immediately below the balloon (flight height = camera height). A captive balloon can be used where the wind strengths are very low. However, because of the relatively large area exposed to the wind, even light to moderate winds have a destabilizing effect (turning and rolling the balloon). A particular disadvantage is the high cost of this method, as a gradual escape of the expensive helium is unavoidable. In addition, when transporting the balloon, at least some of the gas must be let out and later pumped back in. It is an advantage to have a second person to help with controlling and stabilizing the balloon.

A captive kite is a kite with a comparatively large span width and which is so constructed that it can carry a small load and remain as steady as possible in the wind. The camera is attached to the kite line about 30 m below the kite, according to wind conditions (camera height < flight height). Strong winds have a stabilizing effect, as long as there are no gusts. The costs are comparatively small and comprise only the purchase and the replacement of worn parts. A captive kite such as was used here can be folded into a 1.5 m long tube and easily transported. Captive kites are, however, not the same as stunt kites; the steering is done only through the movement of the person who holds the line. In principle, this person can also have control of the camera mechanism, although because of time constraints, it is recommended that teams of two are employed. Where there are high wind speeds, a second person to recover the kite is indispensable.

Remote-controlled model helicopters have the advantage of being used in almost any wind conditions. However, there are considerable disadvantages in the high purchase costs, the difficulty of controlling them and the risk of injury from the fast-rotating blades. The practice time required to be able to properly fly a remote-controlled helicopter is very long.

In contrast to the unmanned methods described so far, the use of an ultralight aircraft makes it possible to take aerial photographs directly and without remote control. The advantage of ultralight aircraft is that they can fly slower and at lower altitudes than other powered aircraft. This makes it possible for the cameraman to lean out of the aircraft (following removal of the door) and take photos almost vertically above the ground. The greater distance above ground level enlarges the targeted display detail, though with a loss of resolution. The hiring of aircraft and pilot has a cost which depends on factors such as the number of photos (flight height, overlapping) and the distance from the investigation area and the landing place.

Following the appraisal of the screening process, final data generation was carried out with flights at two different altitudes:

- with ultralight aircraft for area-wide course coverage
- with a captive kite for high-resolution detail sampling of the focus paddocks

Based on this comparative analysis and following orientation tests using all four methods and the advice of experts who had already had experience with the equipment, a captive kite was used as the carrier system for the collection of meso-scale high-frequency data series (Bürkert et al. 1998). Captive balloons were too unstable in the windy conditions of the mountainous areas of the investigation work, and the steering of the model helicopter proved to be insufficiently accurate. However, the demands of an area-wide survey over the 315 ha of the investigation area could not be fulfilled, so the use of the kite was restricted to the area of the focus paddocks.

In addition, conventional color infrared photography was evaluated: analog color infrared pictures (Bundesamt für Naturschutz 1995) of the area of investigation from the year 1993 were digitized and ortho-corrected. In the following, these are referred to as CIR-Orthophotos 1993. They provide a geometrical reference for all further equalizations.

Infrared light is absorbed to different degrees by the vegetation cover, depending on moisture levels and characteristics of the soil. With the aid of a false color slide film, information on the reflected infrared light can be used to give a better differentiation of the grazing pastures (Kodak Ektachrome Prof. Infrared EIR Film). With the use of CIR films, a dark-yellow filter (Wratten Filter No. 16 or similar) is necessary to prevent exposure of the film emulsion with blue light (<54 μm).

The processing of the pictures was carried out with the help of the remote sensing program ERDAS Image Professional and ERDAS orthobase.

4.1.4
Investigation Design

Aerial Photograph Series from an Ultralight Aircraft

The aerial photographs from the ultralight aircraft provided an overall image of the pastures. Five flights were undertaken at monthly intervals from the end of May to the beginning of October, 2001, in order to obtain the CIR photographs (picture series CIR2001).

In total, 233 photographs in the series CIR2001 were taken and ortho-corrected using the Orthophotos 1993 and a digital site model (DSM, 50 m resolution). By using a mosaic procedure, the individual photographs of a pasture were fit exactly together and resampled to 30 cm image resolution (Fig. 4.2). In this procedure, a color equalization was also applied to the overlapping sections. The result is in each case, an overall image for every pasture and every month of investigation.

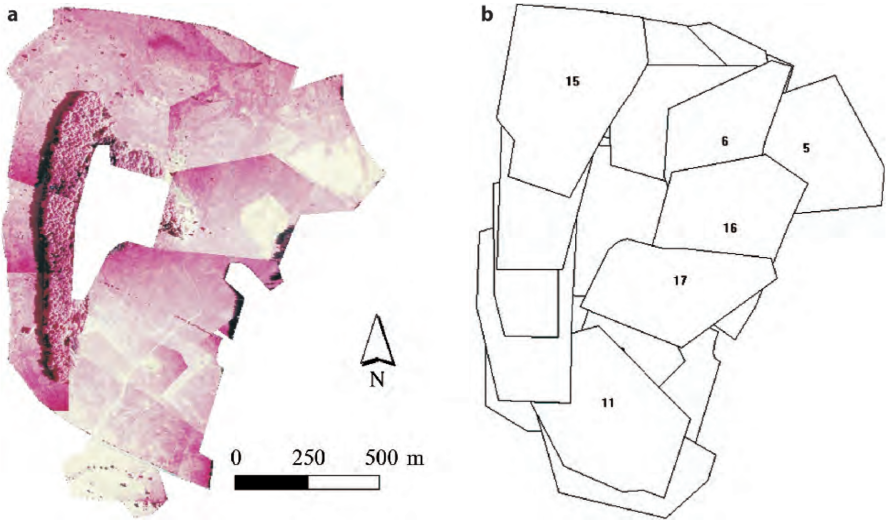


Fig. 4.2. The orthorectification CIR images were composed into a single CIR image of each pasture and time of exposure. The figure shows the Wüstensachsen pastures in June 2001. **a** The resulting mosaic from orthorectified CIR images (the woodland in the center, a fenced conservation area, was removed, as were areas outside the pastures; **b** image edges and overlaps which were used for the color equalization

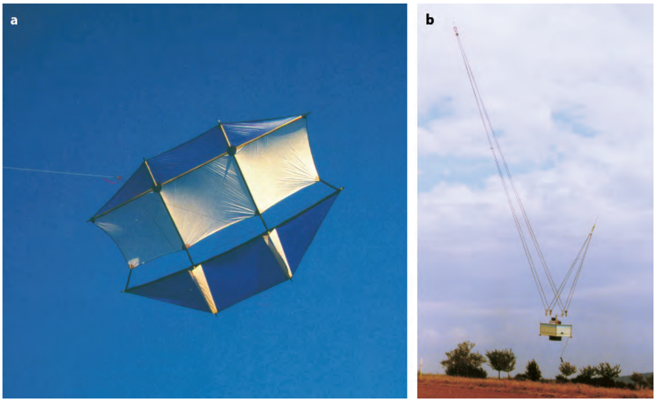


Fig. 4.3.
a Maxi-Dopero kite; **b** Picavet mount and camera rig (montage) (photos: M. Conradi)

Aerial Photograph Series Using a Captive Kite

The kite selected here was a Maxi-Dopero (Doppel-Pearson-Roller) designed by Ralf Beutnagel (Beutnagel 1997) (Fig. 4.3). The span width measures to 3.72 m and the length is 2.55 m. As soon as the kite had gained sufficient stability, the camera was attached to the line using a so-called 'Picavet mount'. This guarantees an orthogonal alignment of the camera to the land surface. The camera shutter is released by remote control and can be turned horizontally. A vertical swivel (for panorama shots) was not included because only perpendicular exposures were required from the flight. The rig is a copy of a camera rig made in the Kassel technical college (Bürkert et al. 1998). The construction was adapted to fit the single lens reflex camera which was used – a Nikon F70 with a 28 mm wide-angle lens.

An effort was made to maintain a steady height of 100 m, which in Germany does not require a permit. If higher altitudes were achieved, it would have been necessary to pay for a special approval permit. The pictures taken in this way covered an area of approximately 6200 m² (see Table 4.1).

Table 4.1. The relationship between camera height and exposure area, independent of the focal length. The information in bold print refers to the target height of 100 m and the mapped area for the selected focal length of 28 mm

Focal length (mm)		**Camera height (m) = height of kite minus 25 m**					
		50	**75**	**100**	**150**	**200**	**250**
24	Length	75	112.5	150	225	300	375
	Width	50	75	100	150	200	250
28	Length	64	**96.5**	129	193	257	321
	Width	43	**64.5**	86	129	171	214
35	Length	51	77	103	154	206	257
	Width	34	51.5	69	103	137	171
50	Length	36	54	72	108	144	180
	Width	24	36	48	72	96	120

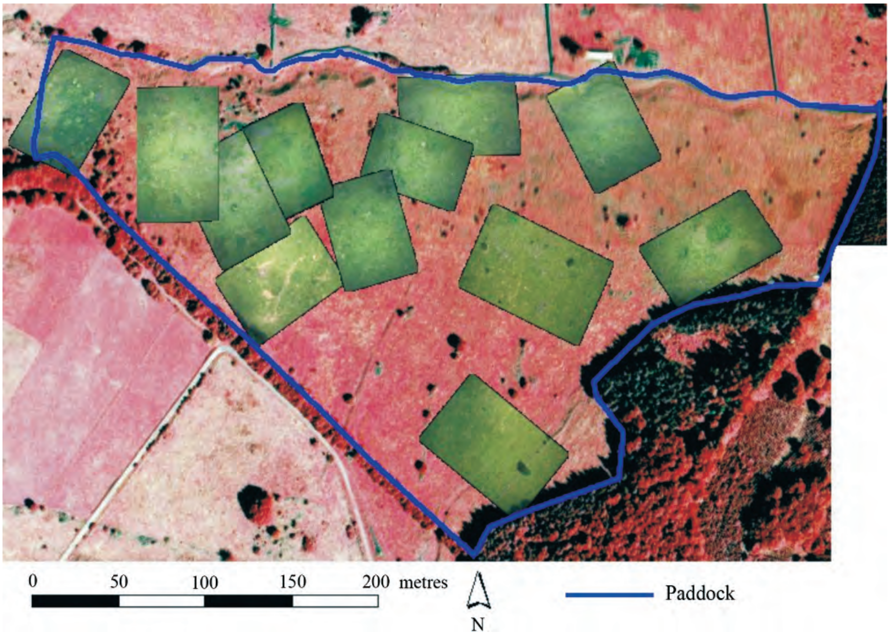


Fig. 4.4. Distribution of the random sample exposures on a focus paddock in June 2001. For the background, the basis reference of the CIR Orthomosaic was selected

The aerial photographs from the kite were random sample exposures (Fig. 4.4), that is, they do not represent the whole area of each particular paddock. The characterization of the entire paddock was derived from the averaged parameters from the samples. The flights with the captive kite were repeated three times between June and October 2001. In total, 328 color slides (Fujichrome Sensia 100) were obtained with the kite and were later scanned in with 600 dpi.

The aerial photographs obtained were geometrically equalized using a polynomial correction algorithm and were resampled to a standardized resolution of 4 cm pixel size. In order to reduce redundant information, a selection process was used in which strongly overlapping photographs were excluded, which reduced the number down to 224. In this way, about 10 photographs per focus paddock and month were available for further evaluation. There were deviations from these mean values in the case of very small or very large paddocks. As a rule, over 50% of the paddock area was surveyed with this method. The RMS value for the mean positional error with respect to the geometrical equalization amounted to 1.32 m (derived from 40 survey points).

4.1.5

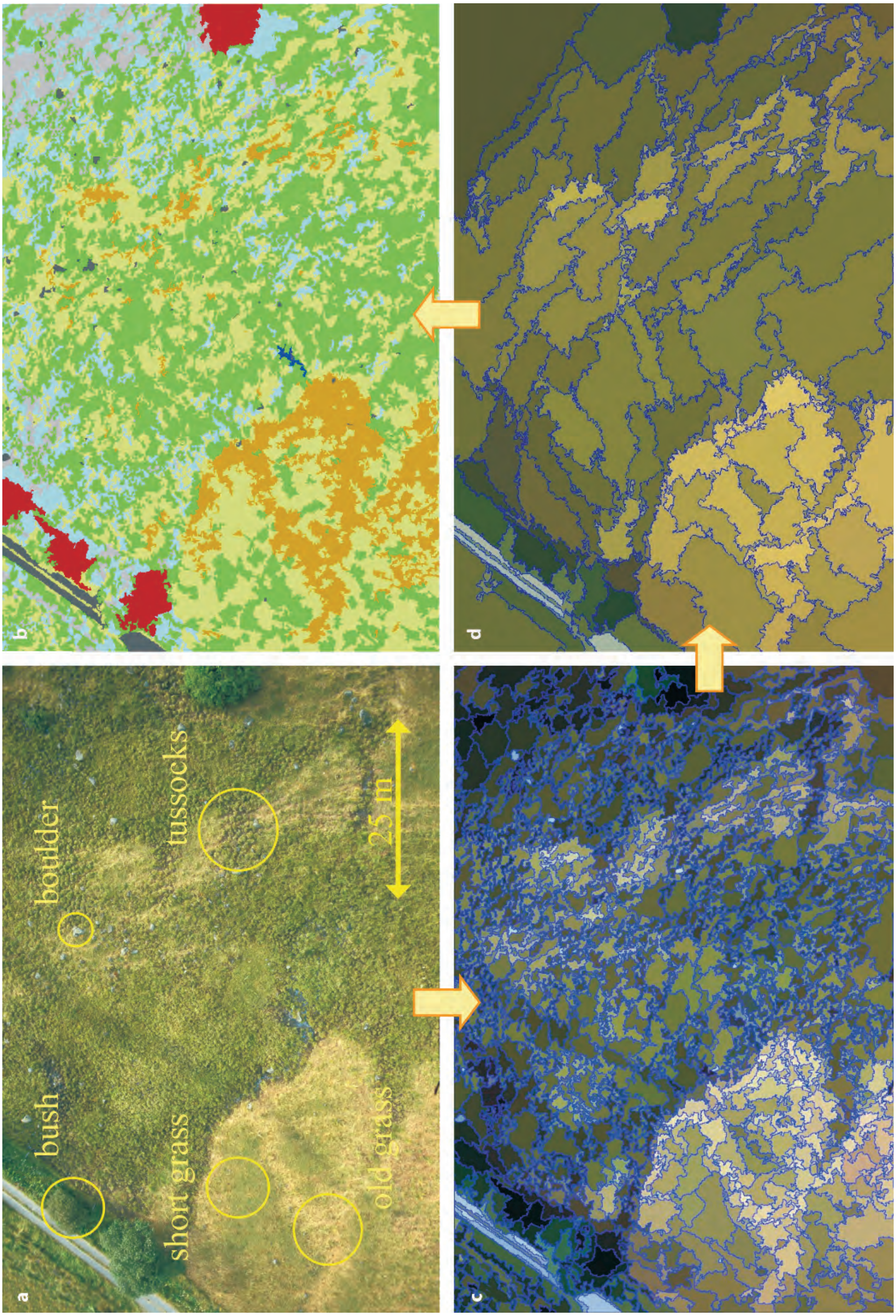
Object-Orientated Image Processing

Segmentation

It has been usual up to now with automated processing of digital image data to classify single pixels on the basis of their (color) value (for example, maximum likelihood procedures; Baatz and Shäpe 2000; Crawley 2002). The spatial position of the pixel to be classified was not considered. In this way, the information that there is a higher probability that neighboring image points belong to the same class compared to points from more distant regions was not taken into account. The consequences were that results obtained with these methods were frequently characterized by mixed and wrongly classified pixels of different allocations (the so-called salt-and-pepper effect).

One approach aimed at making other information sources as well as the single pixel values available for the classification is to separate the image into segments (image objects) which are as far as possible homogeneous. Particularly for very high resolution images, there is a clear improvement in the signal-noise ratio (Pilz and Strobl 2002). The process of segmentation using the eCognition software of the Definiens company is based on a fractal hierarchical concept (Baatz et al. 1999).

By means of a threshold value input (Scale Parameter) for the underlying homogeneity criterion, the mean size of the image object corresponding to the target object to be extracted can be freely chosen (Fig. 4.5b,c). This means that both color as well as form characteristics of the image object can be drawn on (Baatz and Schäpe 2000). The fact that the various target objects (for example, grass clump or tree) can best be imaged on different scales is allowed for by the software, which makes segmentation possible on as many levels as are required (multi-resolution segmentation). The result of this is a hierarchical arrangement of corresponding above and below objects. The relationship between the levels can be used for the analysis of important and ecologically relevant features of the patch structure (Blaschke et al. 2001).


a
bush
boulder
tussocks
short grass
old grass
25 m
b
c
d

◀ **Fig. 4.5. a** Original aerial photograph; **b** segmentation – fine; **c** segmentation – coarse; **d** classification result. The default coloring of the segmented image object corresponds to the relevant mean value of the color value of the object and the arrow indicates the sequence of actions

The following features (among others) were differentiated, which were given in the form of an absolute value or a statistical distribution parameter (mean value, range, variance, standard deviation SD etc.):

1. color, for example:
   a mean value of an object
   b SD of an object
   c mean SD of neighboring objects
   d mean SD of lighter/darker neighboring objects
   e mean SD of the whole scene
2. form, for example:
   a area
   b range
   c ratio range to area
   d shape Index
   e main orientation
   f relative, common borderlines to over object
3. texture, for example:
   a mean SD of the pixel value of the under object of an object
   b mean value and SD of the under object area of an object
4. context, for example:
   a number of neighboring objects
   b number of under objects

The indices represented here can be used to describe the heterogeneity and the complexity of the structure elements. In this case, care must be taken that many of the features correlate closely to each other and therefore do not contain any additional information (Gustafson 1998).

Classification

Following segmentation is the process of classification. In the first stage, a list was made with the fifteen classes which are considered to be relevant. The listing process was based on a hierarchical model (Fig. 4.6), based on the assumption that all objects can be assigned to the three groups:

a affected by vegetation grazing
b affected by trampling
c not affected, or effects not recognizable on aerial photographs

The objects in group a were separated according to vegetation height and flower abundance, in order to produce a 3 × 3 matrix. The item 'high, flower-poor vegetation'

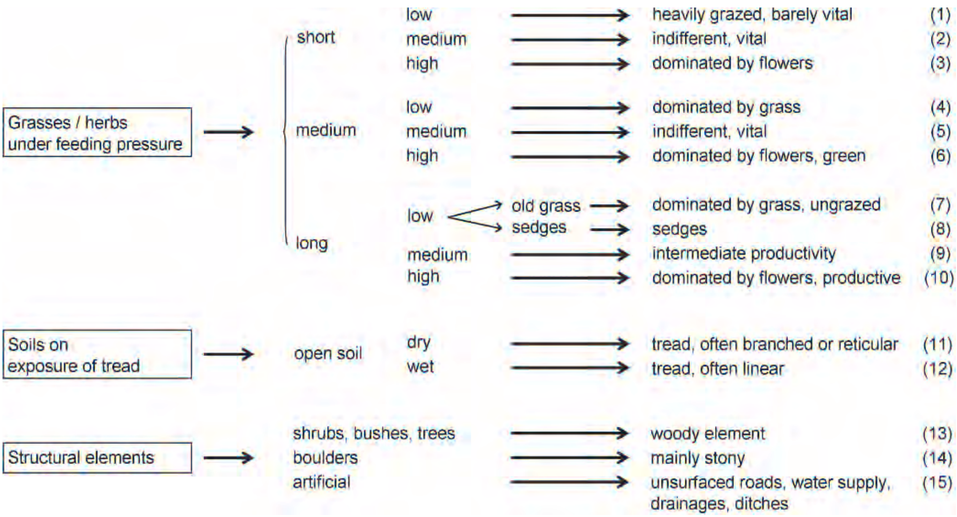

Grasses / herbs under feeding pressure
short
medium
long
low
medium
high
old grass
sedges
heavily grazed, barely vital (1)
indifferent, vital (2)
dominated by flowers (3)
dominated by grass (4)
indifferent, vital (5)
dominated by flowers, green (6)
dominated by grass, ungrazed (7)
sedges (8)
intermediate productivity (9)
dominated by flowers, productive (10)
Soils on exposure of tread
open soil
dry
wet
tread, often branched or reticular (11)
tread, often linear (12)
Structural elements
shrubs, bushes, trees
boulders
artificial
woody element (13)
mainly stony (14)
unsurfaced roads, water supply, drainages, ditches (15)

Fig. 4.6. In order to classify the aerial photographs from the kite method, a class hierarchy with 15 classes was created

was further broken down into 'large-sedge dominated plant communities' and 'ungrazed grass grown to seed', or grass not completely eaten by the cattle.

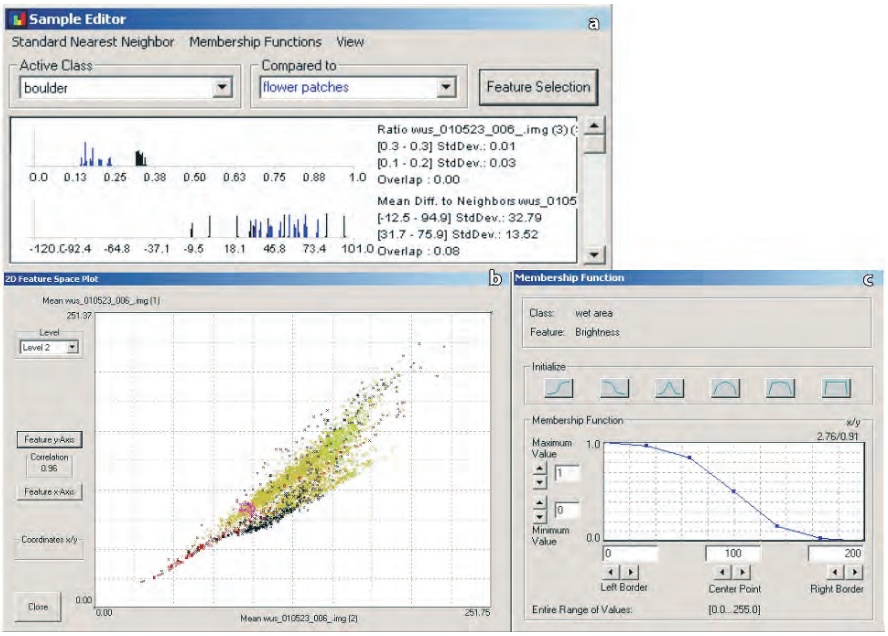
The objects of group b were separated into the moisture categories dry and wet.

The objects in group c were considered as structural elements of a pasture. The intention was to test the extent to which they were affected by the mobility behavior of the cattle. This group included bushes, trees, large stones and structural elements which were man-made, such as drinking troughs and drainage ditches.

Typical image objects were selected as so-called 'samples' from inside the levels to be classified and assigned to the respective classes. The samples correspond to the training areas of a supervised classification. This makes it possible to have a first, provisional classification based on the 'nearest neighbor algorithm'. In this way, most of the image object is already correctly classified.

A closer observation, however, still shows a series of wrongly classified objects. The classification results can only be iteratively improved in two ways.

1. *Optimization of the sample selection process:* For the separation of spectrally similar classes, the frequency distribution for feature values of two features can be compared directly with each other in the sample editor (Fig. 4.7a). A second possibility is the arrangement of two features in the 2D feature space plot (Fig. 4.7b).
2. *Fuzzy membership functions:* Membership functions are assignment rules which allocate an object of a particular class with a value between 0 and 1. A curve, which can be changed by the user, defines the assignment rule (Fig. 4.7c). The assignment is therefore fuzzy (imprecise) because in contrast to Boolean algebra, the object belongs not just to one class but can be simultaneously in several classes. During the final classification process, the object is assigned to a particular class according to its assignment rank (fuzzy value).



Active Class: boulder

Compared to: flower patches

Ratio wus_010523_006_.img (3)

[0.3 - 0.3] StdDev.: 0.01

[0.1 - 0.2] StdDev.: 0.03

Overlap : 0.00

Mean Diff. to Neighbors wus_0105

[-12.5 - 94.9] StdDev.: 32.79

[31.7 - 75.9] StdDev.: 13.52

Overlap : 0.08

Level: Level 2

Correlation 0.96

Class: wet area

Feature: Brightness

Maximum Value: 1

Minimum Value: 0

Left Border: 0

Center Point: 100

Right Border: 200

Entire Range of Values: [0.0...255.0]

Fig. 4.7. Improvement of the classification result with eCognition. **a** Definition analysis of the features in the sample editor and **b** in 2D feature plot; **c** membership function

The rules needed, for example, to assign objects to the class 'large stones', could be: shape index < 1.6; brightness > 170; area > 0.2 and < 1.0. With the fuzzy approach, the boundaries are dealt with imprecisely, meaning that an object with a shape index of 1.8 still has a membership to the class 'large stones', even when the rule shape index <1.6 is not met. The framework of rules that was set up for the classification of an image can be transferred to other similar images. However, a rather time-consuming manual adaptation is necessary.

4.1.6
Variable Reduction with the Help of Multivariate Analysis

Each object can be described using a number of different parameters. If one combines the potential available from both programs – eCognition (feature values) and Patch Analyst (landscape metrics, ArcView Extension based on FRAGSTATS) – then it is possible to generate over 100 variables. From this range of variables, 28 were selected based on their suitability (see legend for Fig. 4.8). In order to exclude closely corresponding variables and therefore reduce their number further, a principal component analysis (PCA) was carried out with the help of the CANOCO 4.5 software (Jongman et al. 1995; Leps and Smilauer 2003).

For the dataset from the kite photographs, 224 of these were analyzed as samples. If all 28 variables are considered, then 54.5% of the total variance is represented in the first and second axes (43.4% and 11.1% respectively – Table 4.2).

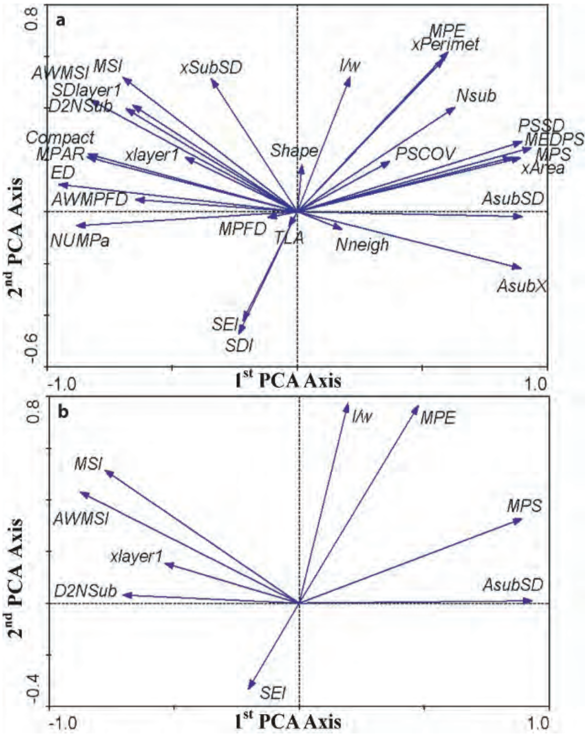


Fig. 4.8.
Principal Component Analysis (PCA). **a** With inclusion of all 28 variables; **b** reduction to 9 variables. *Landscape Metrics:* (1) *AWMPFD:* area weighted patch fractal dimension, (2) *AWMSI*: area weighted mean shape index, (3) *ED:* edge density, (4) *MEDPS:* median patch size, (5) *MPAR:* mean perimeter area ratio, (6) *MPE:* mean patch edge, (7) *MPFD:* mean patch fractal dimension, (8) *MPS:* mean patch size, (9) *MSI:* mean shape index, (10) *NUMPa:* area weighted number of patches, (11) *PSCOV:* patch size coefficient of variance, (12) *PSSD:* patch size standard deviation, (13) *SDI:* shannon diversity index, (14) *SEI:* Shannon eveness index, (15) *TLA:* total landscape area; *Feature Values:* (16) *AsubSD:* SD of area of sub-objects, (17) *AsubX:* mean area of sub-objects, (18) *compact:* compactness, (19) *D2Neigh-Sub:* mean difference of color to neighbors of sub-objects, (20) *l/w:* length/width ratio, (21) *Nneigh:* number of neighbors, (22) *Nsub:* number of sub-objects, (23) *SDlayer1:* SD color, (24) *shape:* shape-index, (25) *xArea:* mean area, (26) *xlayer1:* mean color, (27) *xPerimet:* mean perimeter, (28) *xSubSD:* SD of mean color of sub-objects

Table 4.2. Summary of the PCA results with **a** all 28 variables and **b** the reduced variable selection

Axis	1	2	3	4	Variance (total)
a All 28 variables					
Eigenvalue	0.434	0.111	0.095	0.064	1.000
Cumulative variance (%) of category data	43.4	54.5	64.1	70.5	
b Reduced to 9 variables					
Eigenvalue	0.414	0.191	0.131	0.105	1.000
Cumulative variance (%) of category data	41.4	60.5	73.6	84.1	

If one drops the perpendicular line from the arrow point to an axis, then the section between the intersection and the derivation gives the meaning of the variable for the construction of the axis. This means that variables with short arrows will contribute little to the explanation of the total variance. In addition to this, arrows which are separated only through a very acute angle show a close correlation to the underlying variables. Through interpretation of the PCA diagram, 19 of the 28 variables could be taken out because of the redundant information. The number of relevant variables is therefore reduced to 9 (Fig. 4.8). The variance (60.6%) explained through the PCA model improves slightly compared to the model with 28 variables in that the first axis loses significance but the second axis makes a gain (Table 4.2).

4.1.7
Conclusions

Based on the test methods described here, the following technical conclusions can be drawn:

1. The two-scale structure survey using a captive kite and an ultralight aircraft proved to offer a targeted approach, as it allowed a wide-area course survey to combine with high-resolution detail sampling. In windless or light wind conditions, however, the captive kite could not be employed. These periods of downtime could be reduced through weight savings with respect to the protective housing and through the use of a lighter camera.
2. The aerial photographs which were obtained using the captive kite as a carrier system meet the requirements for the resolution (4 cm) and survey area (about 0.6 ha). They are virtually orthogonal exposures and have a good picture quality.
3. The ortho-rectification and classification of the aerial photography is very time-consuming. A reduction in the number of photographs by flying the ultralight at a higher altitude would reduce the time needed. The deterioration in the resolution resulting from this would be acceptable.
4. An exact understanding of the investigation areas is necessary for both the georeferencing and the classification and cannot be obtained from the photographs alone.
5. The multi-scale segmentation proved to be an advance on pixel-based classification procedures. Information from different levels could be combined.

The method set used here appears at first to require a relatively large effort when applied to practical questions. However, this is mainly because the available survey and evaluation components were used here for the first time in this form of combination. All the basic tools of the methods are available in fully developed forms. If they were combined into a routinely useable packet, their application for practical evaluation tasks in medium-sized, relatively structurally diverse areas would be quite conceivable. The procedure described here can therefore be applied to a wide range of medium-scale structure analyses in the fields of research, nature conservation and planning.

However, the ‘strengths’ of the procedure lie in the fundamental clarification of the significance of small-scale and ephemeral heterogeneity in medium-sized landscape sections for the emergence of species variety. This first experimental application proved convincingly that structural heterogeneity is largely capable of being formulated and documented. Accordingly, cattle grazing has a diverse, highly dynamic micro-structure, which possibly explains the presence of some rare species, despite the rather monotone appearance of the vegetation structure at the time of the survey.

Acknowledgments

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4.2
Mesoscale Vegetation Structure Analyses

Andrea Bontjer

4.2.1
Introduction and Statement of the Problem

The influence of grazing livestock never affects the entire area at the same time and to the same extent. Meadows may at certain times offer a wider range of resources for wild animals which would be lost over the whole area after mowing within a few hours, while pastures offer a narrower but alternatingly continuous resource availability.

Working methods which investigate these circumstances have to be able to sufficiently resolve the distinctive features of the quickly-changing spatial grazing effects and the heterogeneity within the area. The selection of a suitable spatial scale must be given careful attention (McCoy and Bell 1991). The basic unit of such an investigation must be the individual grazing area as a whole. Small scale plots measuring a few square meters will allow a more exact analysis of the species populations and structure with frequent repetitions and are therefore suitable for specific microscale investigations. However, the extrapolation from structural data derived from small-scale work, 'from point to field', which may, for example, make sense in the mapping of mainly homogenous meadows, would not be appropriate with respect to the heterogeneity of a temporally and spatially distinctive grazed area and cannot give a representation of the dynamics covering the whole area.

Area-wide sources of data such as aerial photographs are not generally available as high resolution data series over time (at least 3–5 exposures per grazing period), and therefore do not give sufficient consideration to the time factor. One exception here is the use of aerial surveys, as described in Sect. 4.1, but these have the disadvantage of requiring considerable costs and effort and are limited by weather conditions in their application and frequency.

The following section describes a method of collecting area-wide data on vegetation structures at a meso-scale level, without expensive resources. The structural resolution is less here than traditional resolutions used in vegetation studies but is sufficient to represent the spatial-temporal dynamic of the particular area.

4.2.2
Description of the Method

4.2.2.1
Procedure

From 2001 to 2003 on an experimental pasture (with set stocking and rotational pasture) on the Thuringian Rhoen Biosphere Reserve (Fig. 4.9), overalls mapping of the parameters for vegetation height, grazing pattern, flower occurrence and grazing residues was carried out. All parameters refer to the herbaceous vegetation. Woody species were not considered.

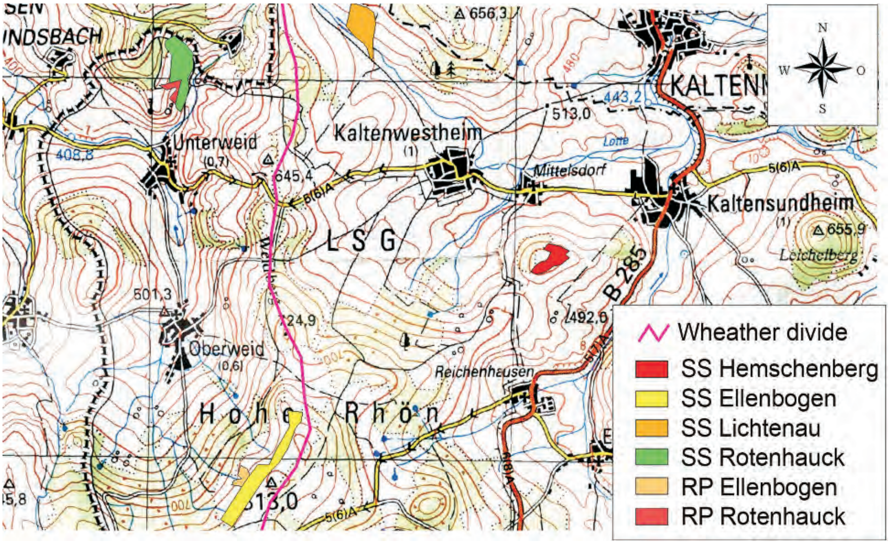


Fig. 4.9. Location of the investigated areas in the Thuringian Rhoen hills (*SS:* set stocking, *RP:* rotational pasture)

The pastures were divided up into visually homogenous sub-units. This type of procedure appears at first glance to be subjective, as it is just these spatial-temporal developments which are to be incorporated. However, in highly dynamic systems, it is no more arbitrary than the more usual sub-divisioning processes with rigid spatial boundaries (cf. Kaiser and Fischer 1997, for example). Additionally, it reflects development aspects and resource availability, which may influence the behavior of livestock, more effectively than purely geometrical units. In the mapping process, each sub-division was assigned to a category which took up at least 50% of the area. The following parameters were arranged into the sub-divisions:

Vegetation Height

The vegetation was divided into height classes:

- <10 cm
- –20 cm
- –30 cm
- >30 cm
- vegetation free

Grazing Pattern

Grazing pattern refers here to any vegetation structure which has clearly resulted from the grazing effects alone of the cattle. In the case of low-growing vegetation, care has to be taken with regard to the relevant grazing effects as the height of the vegetation is also dependent on other factors such as species composition and availability of nutrients. The vegetation was divided into the following grazing pattern classes:

- *vegetation free*
- *short:* the vegetation was grazed uniformly short (<10 cm) and only individual, ungrazed plants remained
- *short with tussocks:* the vegetation was grazed short and individual larger tussocks remained
- *'patchy' on a small scale:* alternating grazed areas and areas of higher vegetation lie close to each other
- *'patchy' on a large scale:* larger areas (over 1 m^2) within higher vegetation were grazed short
- *superficial:* the higher vegetation was only superficially grazed. However, grazing marks are clearly visible
- *nothing:* nothing was grazed, or there are only individual, hardly visible grazing marks

Flower Occurrence

Flower occurrence was divided into four classes:

- no flowers
- few flowers: there are only individual flowers or smaller groups.
- medium flowers: there are denser growths or larger groups of flowers.
- Many flowers: the flowers form a thick carpet.

Grazing Residues

Grazing residues refer to the proportion of vegetation which has not been grazed short at the end of the grazing period. There are four classes:

- *no grazing residues*
- *few grazing residues:* only individual grazing residues or smaller groups (such as tussocks or stinging nettle growths) and coverage is up to 20%
- *medium grazing residues:* coverage of 20–50% for grazing residues
- *lots of grazing residues:* applies for areas with over 50% of the vegetation cover affected

The basis of the mapping system is the use of black-white aerial photograph sections. Each class of a parameter was represented on copies in a specific color. In order to provide orientation for the mapping, site features and structures such as woods and streams which were visible on the aerial photographs were used. The parameters were mapped between three and six times for each grazing period, according to the desired time resolution. The parameter for 'grazing residues' was only registered once, at the end of the grazing period.

4.2.2.2
Evaluation

The assessment was carried out with GIS (ArcView 3.2). The map which was prepared from the site was subsequently digitized on the aerial photograph (Figs. 4.10, 4.12–4.14). For comparative evaluations, the area amounts for the individual classes were added together and represented as an Excel graphic (Fig. 4.11). Because of the high frequency of the exposures, it is possible to make a spatial-temporal representation of the development of the structures and resources on the pasture over the period of the investigation.

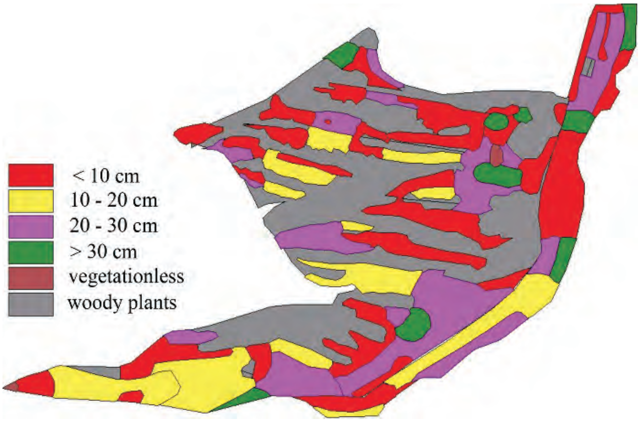


Fig. 4.10. Overall representation of the vegetation heights for the set stocking area at Rotenhauck (20 ha stock density 0.8 LSU ha^{-1}), August 2001

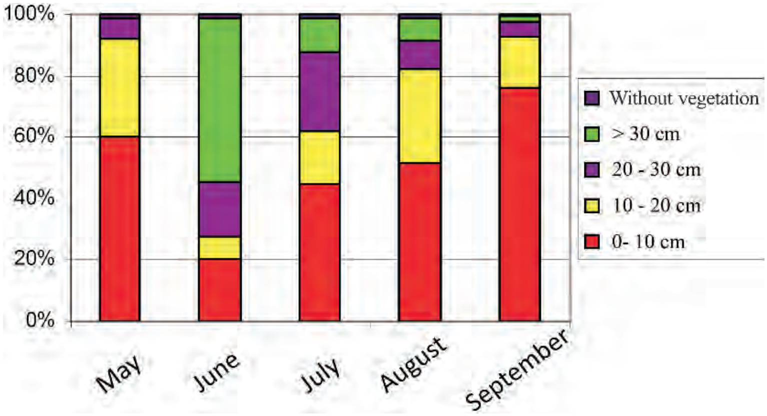
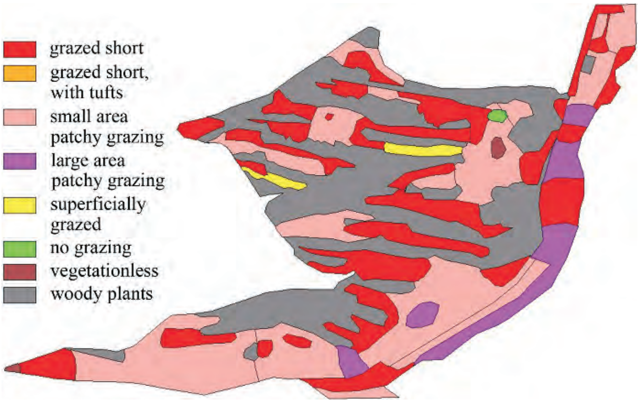


Fig. 4.11. Vegetation height classes for set stocking in Rotenhauck in 2002

Fig. 4.12. Overall representation of the grazing pattern for set stocking in Rotenhauck, August 2001



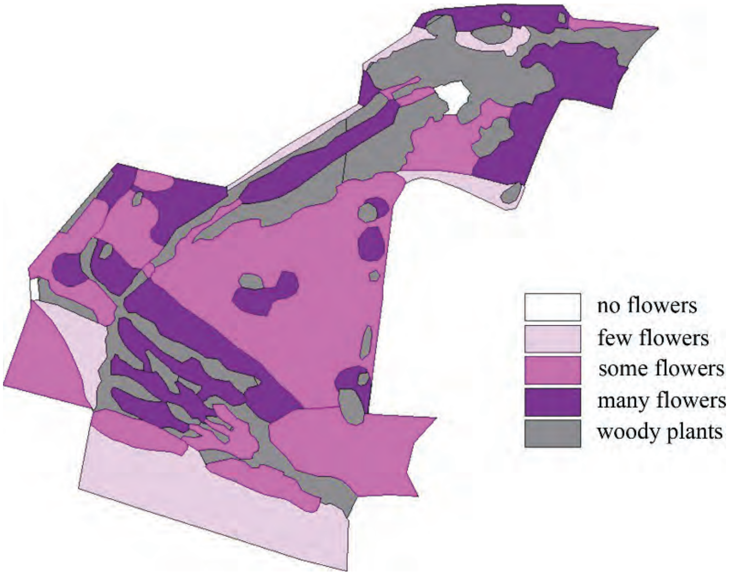


Fig. 4.13. Flower densities on set stocking in Hemschenberg (25 ha, livestock density 0.7 LSU ha^{-1}), August 2002

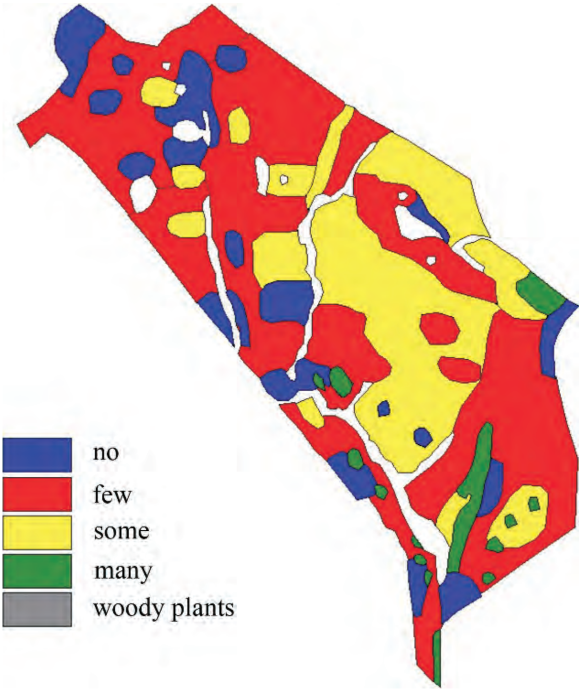


Fig. 4.14. Grazing residue on set stocking at Lichtenau (50 ha, livestock density 1 LSU ha^{-1}) in 2002

4.2.3
Possibilities and Limitations of the Method

The methods described here offer the possibility of carrying out an area-wide survey of various parameters relevant to grazing or ecology in a relatively short time. For a pasture covering 25 ha, about 8–10 hours (h) of mapping time is required, according to the degree of heterogeneity. This amounts to about 30 min ha^{-1}. It is therefore possible to collect data records and to map several pastures within a limited time frame, enabling comparisons of various surveys of a pasture, or comparisons between individual pastures within a single vegetation period to be made. The evaluation with GIS can be delayed to take place outside of the grazing period. In addition, because the survey does not require a great deal of material input, it is inexpensive.

If the pasture has sufficient site features such as woods, streams and permanent trails which are recognizable on the aerial photograph, it will be possible to use these for orientation during the mapping process, dispensing with the need for GPS equipment, range finders or similar assistance. Problems can arise with orientation in pastures that do not have striking site features. There, it may be necessary to use appropriate equipment such as (cattle-proof!) site markers and GPS.

In the past, surveying of the structure was spatially limited to test squares within a largely homogenous area, or to transects – for example, within the framework of a vegetation survey in accordance with Braun-Blanquet or Londo – in which height and density of the various levels were recorded (e.g., Dierßen 1990). The advantage of these methods is that a large number of samples are taken, giving the possibility of obtaining a quantitative evaluation. If the survey takes place within a homogenous area, the results can be mapped right across the area. In this way, however, the level of detail which exists, even in a more or less homogenous section of a pasture, is leveled out. This means that the labor-intensive structural survey of lots of individual sample areas needed for the area-wide mapping of the results offers no advantage over the method introduced here. However, in order to detect small-scale changes in the structure which are leveled out through the area-wide mapping process, a combination using microscale methods adapted to the particular requirements would be sensible.

In summary, the method described here is suitable for surveying the development of vegetation structures in narrow time frames at the meso-scale level. It represents therefore a good compromise between the requirements of 'area-wide', 'data series' and 'accuracy'.

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4.3

The Use of GPS and GIS for an Overall Analysis of Large-Scale Grazing Systems: a Case Study from Oeland (South Sweden)

Inga A. Roedenbeck

4.3.1

Introduction

The vegetation and structure of pastures are determined primarily by the spatial behavior of the livestock. On large-scale pastures, it can be expected that this behavior will be widely varied and therefore, the surveying and area-wide analysis will be subject to a number of methodical difficulties. It should also be noted that the different expressions of livestock behavior (grazing, excretion, migration etc.) produce quite varying ecological effects, and these expressions are subject to a high spatial-temporal variance, in both the course of a day as well as the course of a year. As a consequence, pronouncements about these effects or the derivation of causal connections between livestock and the established structuring of the pasture require high-frequency, continuous and area-wide data capture over long time periods to be valid.

One possibility of collecting continuous data on a higher scale level on the spatial-temporal behavior of the herbivores which shapes the ecosystem is the use of GPS modules and the evaluation of the collected data through geographical information systems (GIS). In order to test the necessary technology on the meso-scale level, two different GPS modules were used on Oeland, south Sweden in summer 2002, and their evaluation potential was checked with GIS. The focus was on a suitability comparison between *(a)* GPS integrated in a collar fit to the animal with automatic data-recording and *(b)* GPS-supported manual recordings of the locations and particular behavioral features carried out by an accompanying observer.

4.3.2

Investigation Area

The island of Oeland is outstanding in the extent and historical continuity of the livestock grazing system on the Great Alvar Plain ('Stora Alvaret') (cf. Petterson 1965) (Fig. 4.15). The Alvar derives its name from the geological strata: the 'alv' is a level limestone layer under extremely shallow karst soils (Johansson 1978). Since the early Neolithic period, the continuous use of these low-yield soils as pasture land created a largely treeless landscape. The long period of use of the Alvar as an 'Allmende', or common grazing land, is still practiced in many places today where historical livestock pastures (mainly cattle and sheep) are managed in plots of several square kilometers with a high degree of continuity.

For the investigation described here, a cattle pasture of 6.4 km^2 in the center of the southern part of the island was selected. The investigation area has a length of almost 4.5 km, extending from the linear village of Resmoe in the west of Oeland to the central dividing wall of the Great Alvar Plain. It was stocked with 64 young cattle in the year of the investigation. The experiments on the site took place between the beginning of May and the middle of August, 2002.

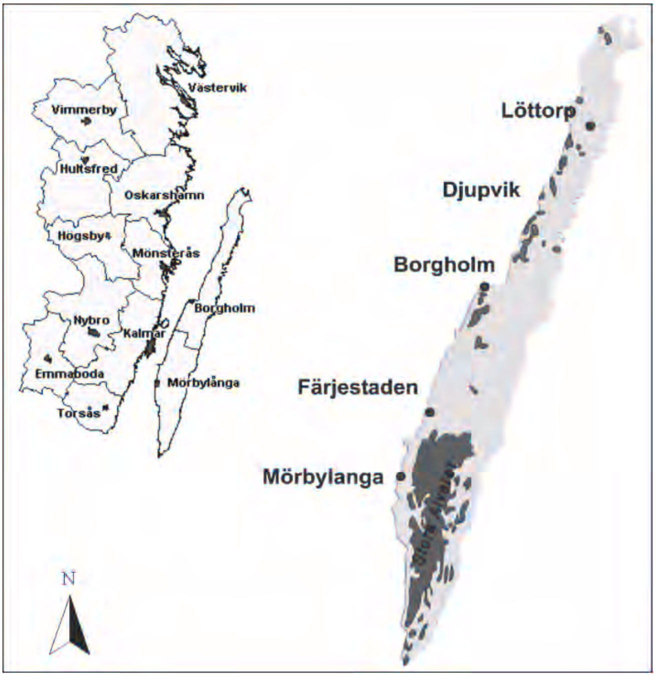


Fig. 4.15.
The location of the Great Alvar ('Stora Alvaret') on the island of Oeland in the Baltic Sea off the coast of south Sweden

4.3.3
Methods

Gps Collar (Type: GPS-PLUS 2TD)

To investigate the movements of the cattle, the second-oldest heifer in the herd of 64 young cattle was fit with a GPS collar in the stall, a day before the herd was let out onto the pasture (May 8, 2002). For the whole of the grazing period, the collar was left on the animal and only removed after 99 days, when the animals were herded off (August 17, 2002) (Fig. 4.16). The hermetically sealed GPS collar (type: GPS-Plus 2 TD) was provided as a test version by the company Vectronic-Aerospace. It consists of three main components (Fig. 4.16, Table 4.3): the GPS receiver is located in the upper part of the battery compartment and the electronics are located in the lower housing. The weight of the collar (about 700 g) is determined mainly by the power of the batteries, and largely prevents the collar from slipping on the animal. The 12-channel GPS receiver delivers two different data sets in time intervals configured by the user:

- *The geographical position* was stored as Cartesian coordinates in the electronic memory of the collar in 30-minute cycles over the whole day. A number of factors were recorded – the positions of the animal, time of day, date and the number of satellites used for the position calculation, which determined the accuracy of the coordinates. Generally, four satellites were necessary for the positioning, and the best results are obtained with a higher number (Zimmermann 2002).

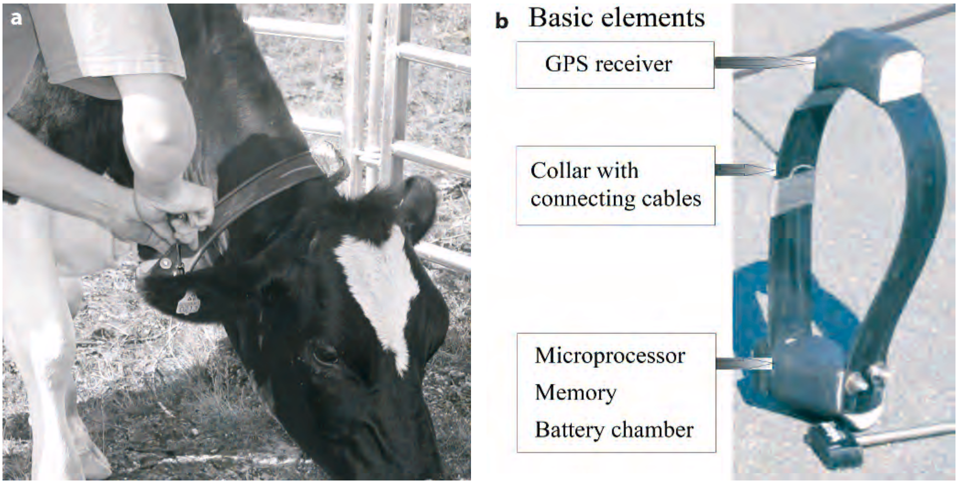


Fig. 4.16. a Fitting the GPS collar, type: GPS-Plus 2TD (photo: E. Rosén); **b** basic elements of the GPS collar (right) (photo: Vectronic-Aerospace, Berlin)

Table 4.3. Technical data on the GPS collar

Type	GPS-PLUS 2 TD
Weight	700 g
Receiver	12 channel GPS-receiver
Battery unit (M: Main, B: Backup)	M: Mrz 40–50 V, B: Mrz 64 V
Dimensions of lower part	66 × 56 × 70 mm
Collar circumference	85 cm
Data	GPS-position, TILT, temp.
Configuration points (interval)	30 min
Configuration TILT (interval)	5 min
Configuration temperature (interval)	5 min
Projection system (Sweden)	RT 90 2.5 gon V 0: –15
Reference ellipsoid	Bessel, 1841

- *Activity ('tilt') and temperature* information was stored in five-minute cycles. The temperature recorded was the temperature in the housing: for activity, accumulated values for the orientation of the electronic module from the horizontal to the corresponding axis were given. That is, the activity was measured from up-down and left-right movements of the head. The accumulated value is a relative measure for the movement characteristics of the animal on a scale between 0 and 250.

After the removal of the collar, the stored data can be downloaded using the 'link manager' on a PC with the software GPS-PLUS®.

GPS Hand-Held Unit (Type: GARMIN-GPS 12)

The flock was accompanied on foot between May and August 2002 in five observation periods, each of three days (7:00 A.M.–8:00 P.M.) and three night sessions (7:00 P.M.–8:00 A.M.). During each observation session, data sets from three information sources were continuously recorded in ten-minute cycles:

- The geographical position was determined with an accuracy of 10 m RMS (Garmin 2002) using the portable GARMIN-GPS 12. Where possible, the virtual center of the flock was used for the determination of position.
- The total number of visible animals and the behavior characteristics of each individual in the corresponding position were manually recorded.
- Location parameters characterize the flock formation (maximum flock radius and mean distance between animals) and the locational features of each geographical position (for example, ground level, vegetation height).

4.3.4
Evaluation with GIS

For the investigation of cattle movements, the geographical positions were recorded with a GIS (ARCVIEW 3.2 – ESRI®) over georeferenced aerial photographs. ArcView has developed a tool – 'Animal Movement' – which offers the possibility of combining the measured point information on movement sequences obtained over GPS. The procedure presents information about walking achievements and speeds of the flock subject to time of day, size of area and weather conditions.

In order to convert the distribution of cattle in space (point coordinates) to an area-wide density map, interpolation techniques were applied. The tool used to do this was the 'kernel homerange' methodology from ArcView 'Animal Movement Analyst Extension' (AMAE). The result of this is the calculation of a grid over the pasture, in which for every grid square, the probability of the flock being present is estimated (Worton 1989). AMAE offers the possibility of selecting contour lines which represent the area-wide density distribution in the form of polygons. The polygons can be created for different probability levels and enclose in each case all squares of the grid which have the same visit probability. The pasture can be graphically represented as a density distribution of the visit points over space.

It is possible to carry out ecologically differentiated analyses through the networking of different, spatially explicit basis data in the form of georeferenced layers (Fig. 4.17).The focus of the investigation was on the intersection of data on the spatial use of cattle and spatial information on the availability of water as the behavior-determining key factor on the pasture. For this, the point coordinates determined with the GARMIN GPS for the shorelines of the water sources were transferred over the *dBase*-Format in a GIS as constant reference points for the livestock activity. To enable the visualization of the water sources, the point information was combined with a function of Xtools from ArcView to so-called 'aspect polygons'. With the parallel-time, GIS-based depiction of spatial use data on the one side, and information on water availability on the other, the spatial interactions can be illustrated.

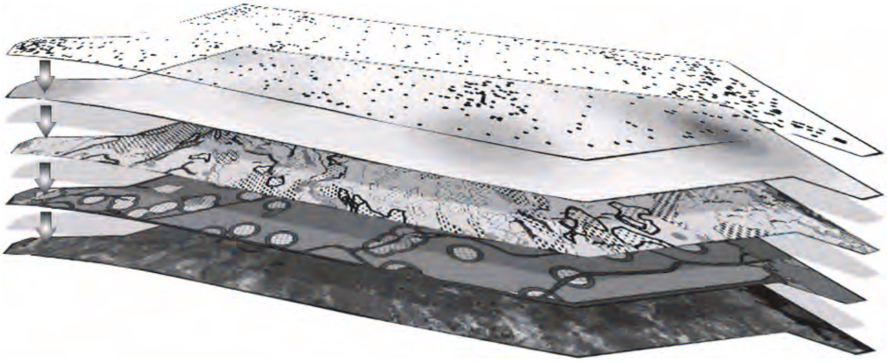
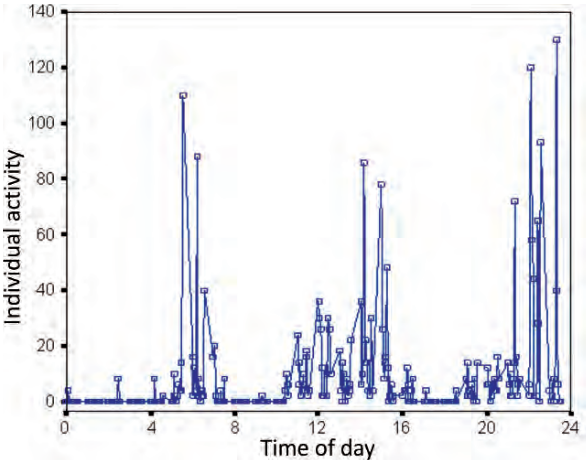


Fig. 4.17. Layer intersection of spatial information. The basis data is provided from digital orthophotos, vegetation maps and spatial use patterns of the grazing animals

Fig. 4.18.
Activity rhythms of the heifer with the collar on July 2, 2002. Movement of the GPS collar from the horizontal determines the recorded activity (up and down movement of the head)



4.3.5
Results from the Case Studies

Activity Rhythms

The daily routines of cattle are shaped by phases of resting and activity. Both phases alternate with each other and together form a rhythmical pattern. The analyses of the data from the GPS collar provided, among other things, the following results: the activity rhythms for all observation days are characterized by a long night-time rest period between on average midnight and 5:00 A.M. During the day, there were alternating periods of on average two to three (in extreme cases, one to four) activity and rest phases of different durations and at different times. Statistically, no connection could be established between the numbers and abiotic control factors (such as the weather). The representation of the activities in the example day in Fig. 4.18 is based on values which come from displacements of the GPS collar out of the rest phase, and therefore the movement of the animal.

Movement of the Flock over the Area

The GIS-based analysis of the movement of the flock in combination with data from the GPS collar and the manual observations prove that cattle on the large pastures of the Alvar orientate themselves with a preference to conspicuous landmarks (prominent trees, water sources, boundaries). Open land was largely avoided because of a lack of orientation points (Fig. 4.19). The herd covered an average of 8.07 km ($\sigma = 2.22$ km) per day with an average speed of 314 m h^{-1}. A comparison with investigation areas in the Black Forest (Kostrzewa 2004) and published sources (Fischer 2001; Hart et al. 1993) indicate that the Oeland cattle have the relatively highest walking activity per day. It is clear that there is a relationship between walking activity and the size of the pasture (Fig. 4.20).

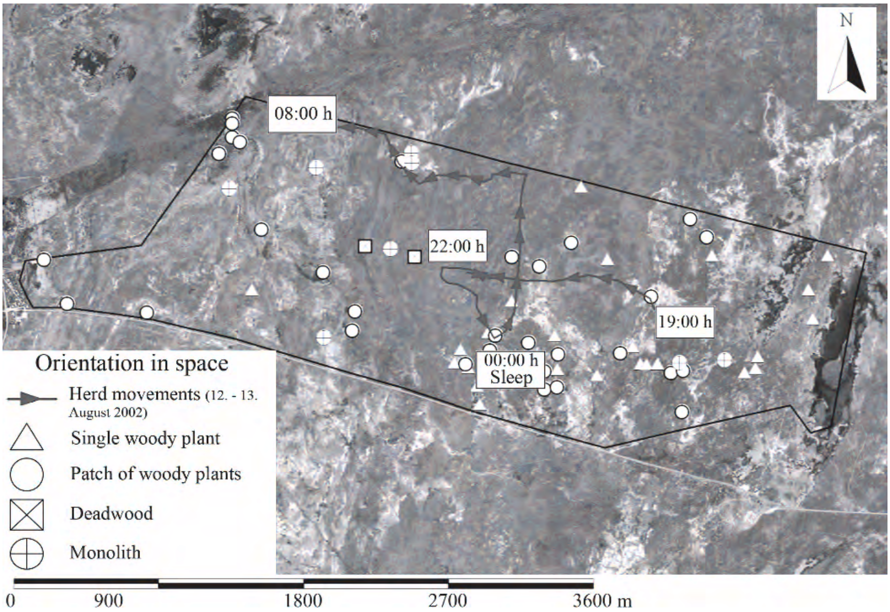
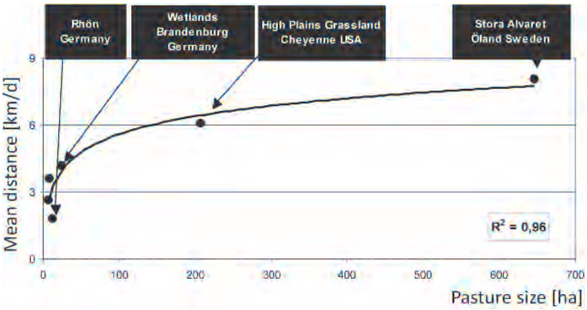


Fig. 4.19. Spatial movement of the cattle herd on a large-scale Oeland pasture on the sampled day (August 2/3, 2002) – created with ArcView 'Animal Movement Extension'. The orientation of the herd in space resulted from the position of landmarks – open land was avoided

Fig. 4.20.
Walking activity of cattle subject to the size of the pasture, with exponential trend line. Investigation results on Oeland in comparison with Conradi (in this book), Fischer (2001), Hart et al. (1993)



Patterns of Spatial Use

In the course of the grazing period, the cattle herd marked out patterns of spatial use (Fig. 4.21). As well as a large proportion of unused area, mainly lying in the center of the land, there are areas of high grazing intensity. In the investigation year 2002, the area of greatest preference was in the west at Resmoe near the drove road and in the east around the groundwater lake *Moeckelmossen*. The focus area for visits in the area south-east of the center (Fig. 4.21) was found to be at two adjacent areas of woody vegetation which are regularly used as night-time resting places. Both areas of woody vegetation are mechanically cleared of undergrowth in the course of pasture management (Åhlund, oral evidence) and form a dark, stall-like protective space with their thickly growing canopy.

Correlation between Spatial Use and Water Availability

Pastureland biocenoses are characterized by numerous spatial, in part mutually-influencing relationships between the abiotic and biotic components, which interact with the environment at different scale levels. Such interactions in the investigation area can be clearly shown through analyses of the spatial availability of water and the land use of the cattle herd which is dependent on this. Because of the special soil conditions of the Alvar, the spatial availability of water is subject to considerable variation during the grazing period. At the time of driving the cattle out to pasture in May of the investigation year 2002, nine constant water resources from eleven water bodies were available. There were no artificial water sources. The soil characteristics and the climate caused the natural surface waters to dry out so that

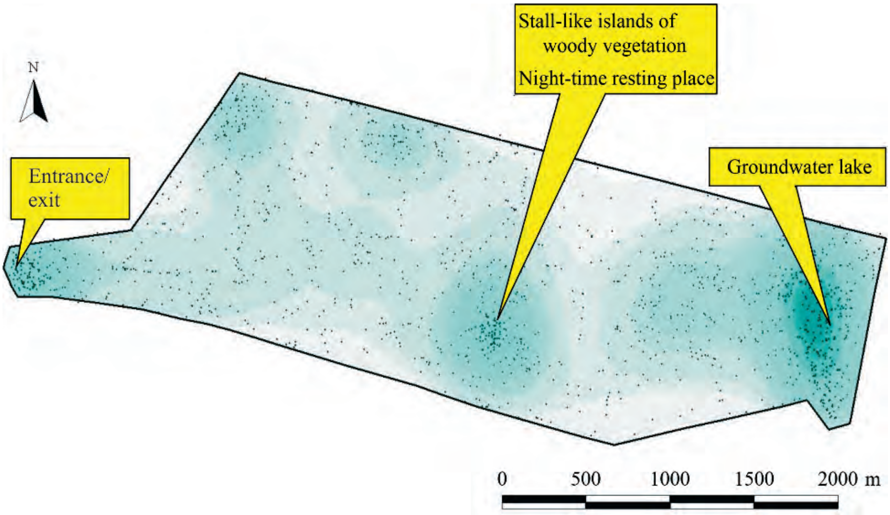


Fig. 4.21. From point coordinates to an area-wide density map – spatial interpolation of 1502 herd records. The positions were measured on a pasture of 640 ha from July 1–31, 2002 in a 30-min cycle with a GPS collar

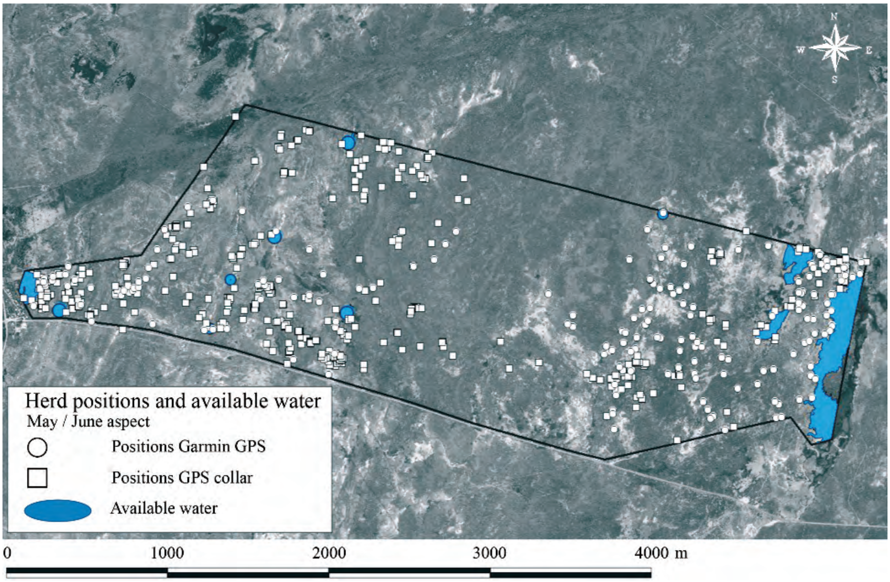


Fig. 4.22. Places frequented by the herd depending on available water – situation in May/June 2002. The extent of the water points were determined with the portable GARMIN-GPS and the places frequented by the herd were determined through a combined evaluation of data from the hand-held equipment and the GPS collar

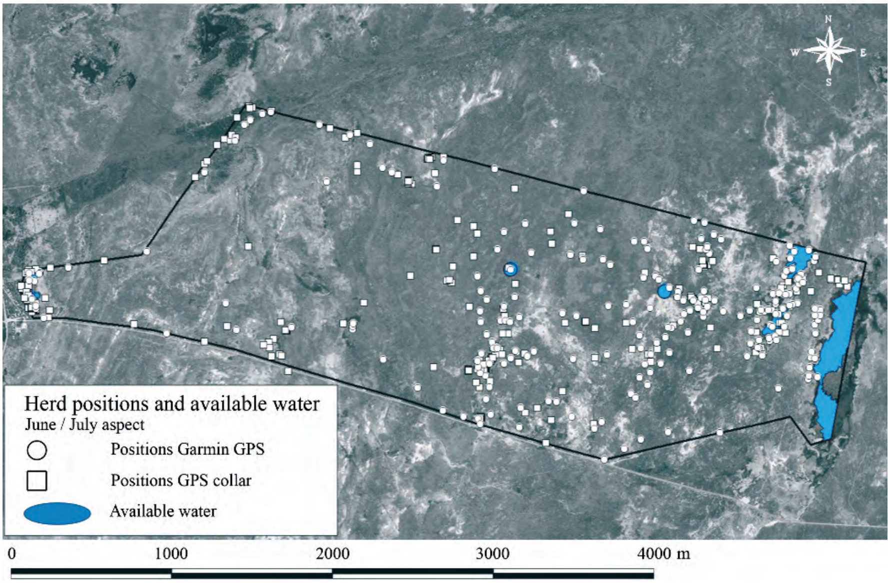


Fig. 4.23. Places frequented by the herd depending on available water – situation in June/July, combined from data through manual observation and data from the GPS collar. With the drying out of the smaller water points in the mid-west of the investigation area, the herd orientated itself increasingly to the wetland to the east and the deteriorating water point at the droving access point (extreme west of the area)

at the beginning of August in 2002, there were only severely reduced groundwater lakes remaining in the eastern part of the area. Because the water points are visited at least once a day, and several times during particularly dry weather (see Sect. 6.3), the land use of the cattle herd was largely influenced on the one hand through the necessity of drinking, and on the other, through abiotic factors. Figure 4.22 shows an aspect at the end of May (investigation period from May 19 until June 03). Here, as well as the groundwater lake in the east and a permanent water point in the west, there are small water bodies in the mid west of the investigation area between which the cattle moved. After the smaller water points had dried out at the end of June (investigation period from June 29 to July 3), the mid-west part of the area was no longer used. The herd orientates itself to the severely degenerated water point at the droving access to the west and follows the available water lying to the east at the wetland round the groundwater lake *Moeckelmossen* (Fig. 4.23).

4.3.6
Discussion

The advantage of the manually collected data lies in the precise and sophisticated mapping of types of behavior at each geographical coordinate. In addition to this, from each position of the observer, as much additional information as required could be collected (for example, vegetation type, ground level, herd radius, individual separation distances of animals etc.). The significance of this compared to the collar is therefore increased. Additionally, the operational reliability of the system can be assured, even during the collection of data. With the GPS collar, operational reliability could only be tested at the data downloading phase, after the removal from the animal. In principle, function testing and data downloads are possible on site with the collar but for this, a different type of model is necessary. More modern techniques make it possible to send information about the locations of the animal once a day via a GSM modem (Global System for Mobile Communication) integrated into the collar, similar to sending a text message with a mobile phone. In 2002, the cost of such a device ran to €4 230 (Vectronic Aerospace 2002, pers. communication), which is an additional cost of nearly €1 600 more than the model used here.

The high cost of a ready-to-use GPS collar such as the one used on Oeland (about €2 850, of which the collar cost €2 380, the battery unit €220 and the software for the data download €220 – Vectronic Aerospace 2002) has to be set against the huge savings of labor and the almost complete independence from weather conditions during the data collection. Quantatively, it delivered double the amount of data (4 588 coordinates over 99 days of operation) than the hand-held data collection system (2 309 coordinates over 31 days of operation). Because cattle follow herd behavior on large-scale pastures, the collection of data from an individual animal via a collar is reliable, although no statements over the radius of the herd or repeatedly occurring divisions of the herd can be made. In order to avoid the situation where a 'maverick' individual is selected to wear the collar, the animal should be observed carefully before the selection. It is particularly important to work closely with the herd owner because of the detailed knowledge over the characteristics of the animals that the owner would possess. A cost-benefit analysis should be carried out before employing the system in the reference area. For smaller pastures, it can be expected that the typical herd behavior will be less than for the conditions observed here. This aspect would considerably reduce the significance of individual data with respect to the whole herd from one or a few collars.

The spatial basis is a decisive feature in many ecological phenomena. Geographical information systems have proved themselves as suitable tools in creating this spatial basis. The extent of the two-dimensionally processed investigation area (640 ha) and its pronounced structure meant that the use of GPS was essential. The levelness of the site and the absence of reflecting macrostructures improve the measuring accuracy of the system. Only 2.16% of all measurements were determined with an insufficient number of <4 satellites. 97.8% of the measurements were made with four or more satellites, giving the best possible position determination. With such optimal site conditions, an average measuring accuracy of the GPS used here can be improved to less than 10 m.

Acknowledgments

The operational efficiency of the GPS collar which was fit to heifer 0213 'Ursula' was possible through the unlimited cooperation and the physical efforts of Gunnar and Tony Åhlund, the farmers of the investigated area, who also provided information about the actual grazing regime. Thanks also go to Dr. Ejvind Rosén (University of Uppsala) and Robert Schule (Vectronic Aerospace, Berlin) for the technical support.

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4.4
High Resolution Serial Data on the Behavior of Grazing Animals through Opposite Slope Photography

Stefan Kostrzewa

4.4.1
Introduction

Most of the published investigation approaches on the recording and assessment of the influences of herbivores on their habitats have until now analyzed the visible or supposed effects on the structure and composition of the vegetation, or other structural elements (cf. Hüppe 1997; Vera 2000; Zimmermann and Renninger 2004). Such approaches make it possible to draw important conclusions (cf. Sect. 4.1 and 4.2) but have limits to how far they can be interpreted as very often, the causes can not clearly be determined. This is particularly the case where a particular structure or species composition is the combined result of several different influences which may either arise alone from the livestock (grazing, grooming behavior, excretion etc.) or from this and other factors (for example, pasture management, weather, other animals in the area). The same is true for the actual conditions, which owe their existence to long, spatial-temporal and often variable chains of effects. A robust analysis of the effects of herbivores, in this case, of livestock, on their habitats should not be orientated alone on the results but should give direct consideration just as much to the behavior of the 'stakeholders'.

Because the behavior of grazing animals changes significantly over short time periods (through weather effects, general nutritional conditions, availability of water etc.) (cf. Sambraus 1978), high-frequency recording techniques are necessary, which at the same time must be precise enough to be related in a second stage to the structure of the habitat – in this case, a grazing pasture. These conditions are difficult to fulfill methodically, particularly if the available place of action (in this case, large-scale pastures) is of considerable size. Questions arise over factors such as the manual observation of the animals and the consistency of this when accompanying the herd, which is limited because of the major time and personnel requirements and by weather conditions (cf. Sect. 4.3, 4.5), while high-frequency point research methods at a lower scale lack a sufficient degree of area coverage. More recently, there has been increasing discussion about the use of automated methods with GPS, data loggers and GIS. They can produce good results under more or less planar conditions (cf. Sect. 4.3) but are less suitable for high-relief investigation areas such as mid and high range mountains.

There is a possibility here to benefit from this very relief in that from neighboring positions, a complete view of the investigation area can be obtained, and this can be recorded with relatively simple techniques through high-frequency serial photographs before going to a subsequent electronic and statistical analysis stage. These methods are particularly valuable if the view over the pasture is undisturbed. Through 'opposite slope photography', high-resolution serial data over relatively long time sequences on the spatial use and behavior of grazing animals can be obtained, with a very low personnel input. However, there is until now hardly any data on the efficiency and the limitations of these methods.

4.4.2
Methodology

Opposite slope photography was set up on the cattle pastures of the Praeg Glacier Valley in the South Black Forest (Baden-Württemberg, Germany) as the recording method for the behavior and movements of the cattle. This former common grazing area is today used for apportioned rotational grazing. The area offers good conditions and possibilities for using this method because of the great height differences and steep elevations. Facing slopes are close to each other on all of the grazed areas. The photographs were taken during the grazing periods in 2000 and 2002, in each case from the end of May to the middle of September.

The basic idea of opposite slope photography is to produce images of the grazed areas, including the grazing animals, from the slope on the opposite side. In order to make this process automatic, two pieces of equipment were set up, each consisting of

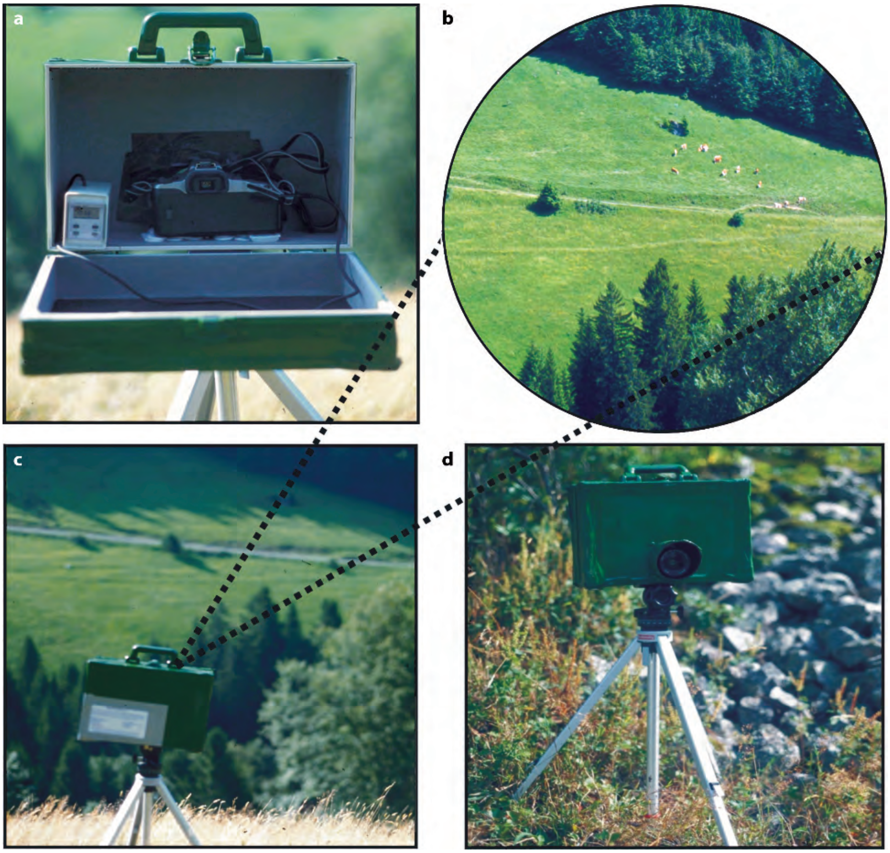


Fig. 4.24. The equipment used for the photography. Camera and timer are installed in a weather-proof housing (**a**) which can be set up even on steep slopes with the help of a tripod (**d**). The camera is focused on the opposite slope (**c**) and takes a photograph every 30 min (**b**) (photos: S. Kostrzewa)

a camera, a remote-control release, a timer and a weather-proof housing (Fig. 4.24). The programmable timer sends an electrical impulse to the camera via the remote-control, allowing photographs to be taken at variable time intervals. In the equipment used here, single-lens reflex cameras of the type Canon EOS 300 und Canon EOS 500 and suitable remote-control releases (RS-60 E3) were used. For both cameras, lenses with focal lengths of 27 to 300 mm were used, subject to the distance and situation of the site on the opposite slope. For the timer device, the model CPU 35u made by the company Mehne was used, which was supplied with power from 1.5-V batteries and can be used in any location. However, as one of the very few 'site-suitable' battery-operated timing devices, the model is technically limited to a maximum of 20 cycle inputs, that is, shutter releases per programming. As there were no better devices independent of main electricity available at the time of the investigation, a relatively long interval of 30 min per exposure had to be selected in order to reduce the attention needed on site to an acceptable level (in the meantime, the development of digital cameras has changed this situation). Because of this technical restriction to 20 program settings and exposures, it was necessary to visit the otherwise automatic set up twice a day in order to reset it. For the weather-proof housing, aluminum cases were used in which aluminum pipes were fit where the lenses could be installed, protected from the weather (Fig. 4.24). With commercially available tripods on which the aluminum case attaches, the cameras could be positioned virtually everywhere on the site. For the film, color slide film (ISO 100) was used.

The photographs produced in this way were then digitized and analyzed in ArcView 3.2 with the assistance of aerial photographs and a digital site model. In this way, the photographs of the places visited by the cattle (digitized/original) were transferred to the aerial photographs in the GIS through an optical alignment (Fig. 4.25). The opposite

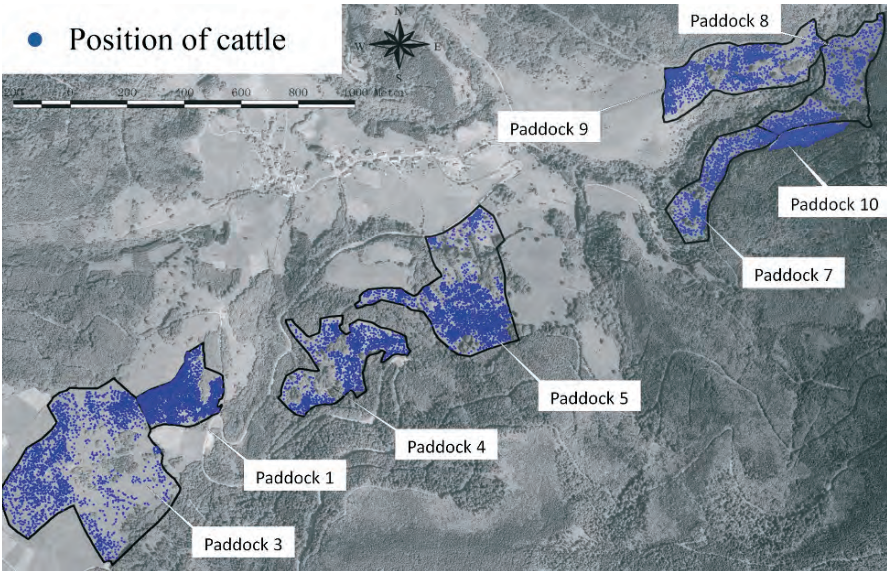
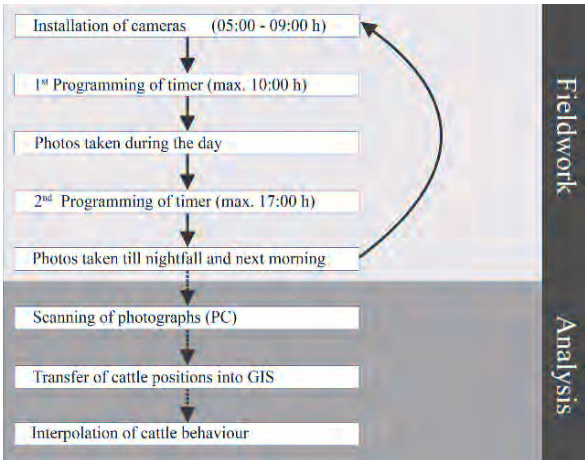


Fig. 4.25. Investigated locations of the cattle in the grazing period in 2002, in the Praeg Glacier Valley (South Black Forest), determined over 436 h of opposite slope photography on 39 survey days. $N = 20\,118$

Fig. 4.26.
Schematic outline of the procedural stages in opposite slope photography


Installation of cameras (05:00 - 09:00 h)
1st Programming of timer (max. 10:00 h)
Photos taken during the day
2nd Programming of timer (max. 17:00 h)
Photos taken till nightfall and next morning
Scanning of photographs (PC)
Transfer of cattle positions into GIS
Interpolation of cattle behaviour
Fieldwork
Analysis

slope photography can be subdivided into a site-dependent outdoor section and an area-independent procedure, just as with 'manual' survey methods (Fig. 4.26).

The extraction of the behavior information in the photographs proved to be more involved than the mere determination of the places visited by the cattle. As this was not observed on the site because of the methodology used, it had to be interpreted from snap-shot images of the photos. Analogous to procedures used in (satellite) telemetry, (e.g., Fielitz 2004), ethological findings were incorporated, concerning how cattle have a typical body language or movement pattern (e.g., Sambraus 1978). In these studies, it was assumed that a particular spatial orientation of a collar transmitter (satellite telemetry) or of the animal's head, in combination with the movement information, could be 'translated' into an unambiguous type of behavior. A defining aspect of the head position was an orientation above or below shoulder height, which signifies a raised or lowered orientation.

Through the application of these methods, five types of behavior could be clearly differentiated on the opposite side photographs. Grazing animals which were found in motion with fully-lowered head were classified as *grazing* (Fig. 4.27). Another type is the behavior classed as *in motion*, where the cattle are moving forward but with the head raised. Lying cattle are classed as *recumbent* (Fig. 4.27), and standing cattle which are not in motion and have a raised head are described as *standing*. An accumulation of animals at a water point are classified as *drinking*, even when this was nor clear from the photographs because of the congestion of cattle seeking water. More complex types of action such as social and grooming behavior, or browsing trees, which require a period of time, remain as non-interpretable action fragments from the photographs.

Depending on the clearness of the view and the properties of the site, there were one or two cameras for each investigated paddock covering different parts of the site.

In the grazing period 2000, weather conditions allowed 45 days of photography and in 2002, this was down to 31 days. With sufficient brightness and varying seasonally in the time between 5:00 A.M. and 10:00 P.M., the photographs were taken at 30-min intervals. In total, 1 397 photographs were taken during the 2000 grazing period and 1 489 in the 2002 period. Most of the photographs could be analyzed (see below for sources of error), so in 2002, for example, this was 1 324 exposures. The photographs for 2002 covered a photo-series of 872 half-hourly exposure intervals, that is, a period of 436 h (Table 4.4).

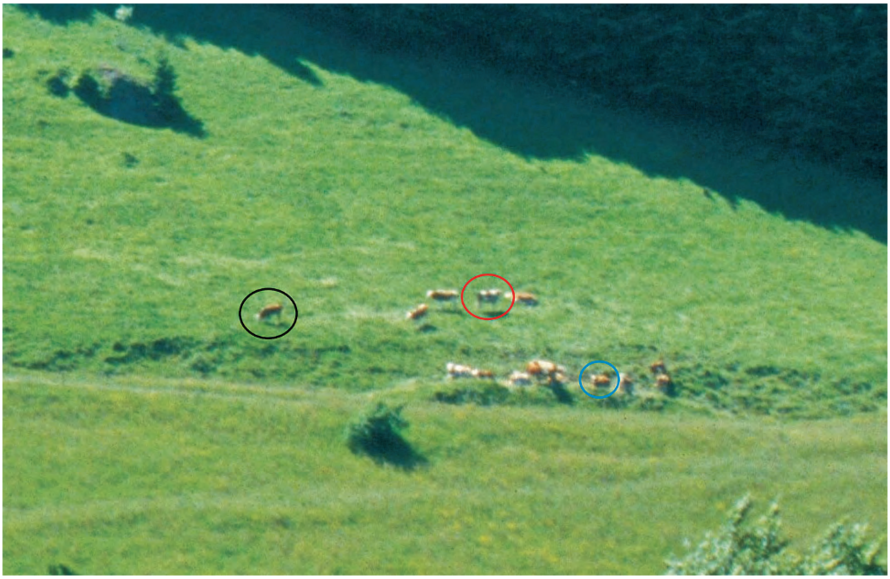


Fig. 4.27. Examples of behavior interpretations from opposite slope photography: grazing (*black*), standing (*red*), recumbent (*blue*). Original photograph: June 14, 2002, 11:30 A.M., Präg Glacier Valley, distance from camera about 400 m (photo: S. Kostrzewa)

Table 4.4. Times of opposite slope photography in the Praeg Glacier Valley in 2002. For each paddock, the number of exposure days and evaluable 30-min intervals is given, as well as the visiting points of the cattle, which was dependent on their numbers and the clearness of the view. [a] Because some of the paddocks were worked in parallel on the same days, the sum of the individual days deviates from the total

Paddock	Date	Day	Exposure interval	Visiting points
1	13.08.–18.08. 2002	6	145	4 917
3	27.08.–28.08.; 01.09.; 06.09. 2002	4	74	2 806
4	06.07.–09.07. 2002	4	73	2 031
5	23.07.–24.07.; 28.07–31.07. 2002	6	116	3 737
7	24.05.–26.05.; 22.08.–23.08. 2002	5	103	1 169
8	27.06.–29.06. 2002	3	86	1 333
9	23.07.–24.07.; 28.07.–31.07.; 13.08.–14.08. 2002	8	175	2 558
10	14.06.–16.06. 2002	3	100	1 567
Total	24.05.–06.09. 2002	31[a]	872	20 118

For the rotational system of cattle grazing in the Praeg Glacial Valley at that time, the paddocks were each stocked twice in the course of a grazing period, which made it impossible to produce continuous photo-series of individual pastures over the course of the year. In combination with phases of poor weather, during which opposite slope photography has limited application, this meant that in some paddocks only one of the two rotations could be surveyed. Because the animals grazed the individual paddocks for different lengths of time, there was a relatively large variation of three to eight days in which photography was possible (Table 4.4). Within this photography period for 2002, a total of 20 118 points visited by the animals of the two herds (50 and 16 animals) over eight pastures could be determined (Fig. 4.25).

4.4.3
Evaluation of the Method

As the use of opposite slope photography is relatively new, there is a complete lack of literature covering experiences of the suitability of the method. The following section makes a first approach to tackling this situation with a consideration of the limitations to application which were found and the sources of error. The main factors were the occurrence of technical problems, the sharpness of the exposures, the animal activity and the classification of the behavior into the five categories.

The parallel working of two sections of a paddock with two cameras was necessary because of the difficult geomorphology and the high numbers of trees, as otherwise, not all areas would have been visible from the opposite slope. This curtailment through geomorphology and tree growth requires the presence of at least moderate weather conditions for the region, in order that opposite slope photography can be carried out. In spite of the weather-proofed construction of the equipment, the operation of the method is restricted by the presence of mist and heavy rain, which occurs frequently in the southern Black Forest. Another problem is that in heavy and persistent rain, the animals – the objects of the photography – look for shelter in thicker vegetation. These wooded areas are difficult to view from the opposite slope, so photo-series had to be discontinued.

Consequently, opposite slope photography is weather-dependent not just because of optical limitations, but mainly because of the behavior of the animals, and cannot be properly carried out if the animals find shelter in thick vegetation during wet conditions. Also during mainly dry periods, when the animals are easy to ascertain, there are occasionally methodological errors, which were, however, relatively few in the test year 2002 with a rate of ~11% (Table 4.5). Again, the weather was responsible for more than half of these errors (6.3%), mainly in the form of sudden changes as well as the constant alternation of different weather situations, which is typical for the higher ground. Here, it is not necessarily the rain which is responsible for the poor quality of the images; rather, it is the accompanying low-cloud formation which occurs on high ground and results in misty conditions. Single clouds or mists can be so thick that they completely obscure the view of the opposite slope, even over short distances. It is particularly paddock complexes which are affected by mist, as in the example shown in Fig. 4.28. Generally, larger distances from the opposite slope result in poorer image resolution as well as greater susceptibility to weather conditions.

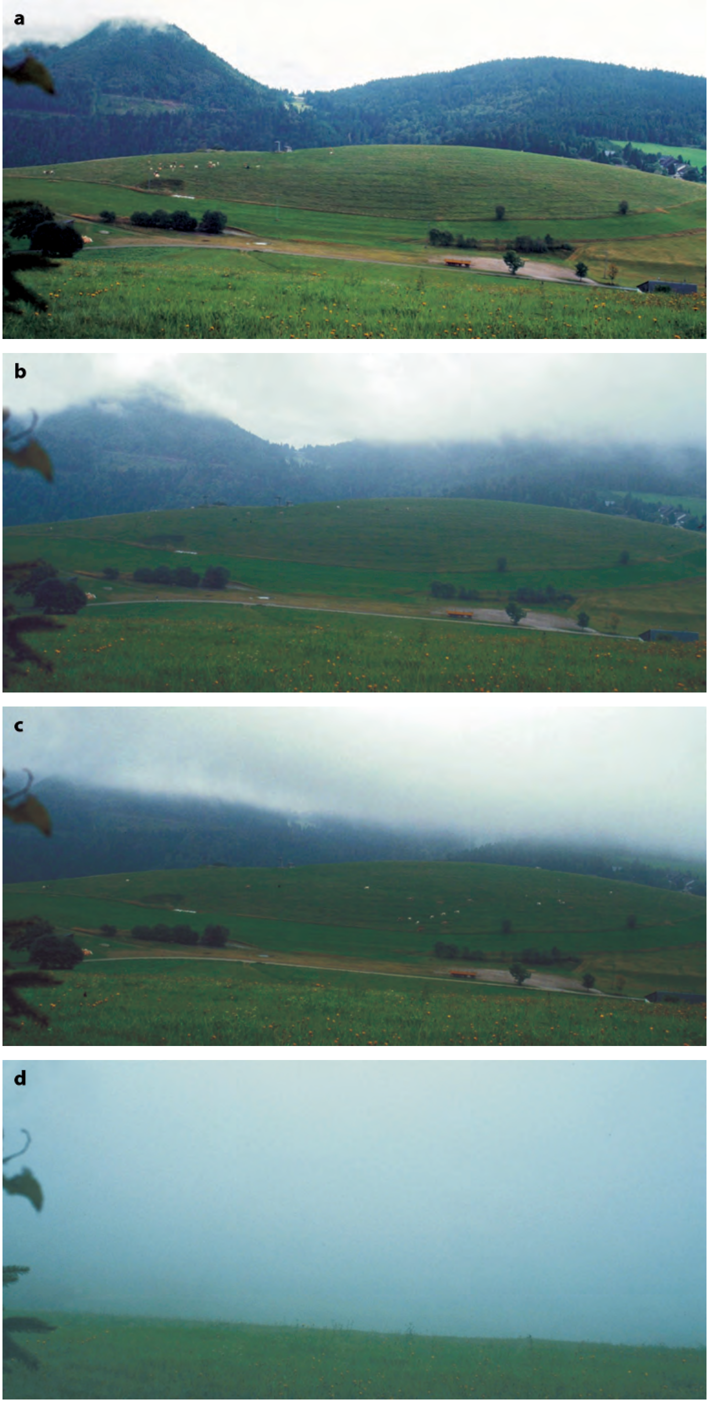


Fig. 4.28.
Weather as a source of error in opposite slope photography. Selected images of the photo-series from a section of paddock 3 (~1050 m a.s.l.) on August 27, 2002: **a** 11:30 A.M., **b** 1:00 P.M., **c** 2:00 P.M., **d** 3:00 P.M. (photos: S. Kostrzewa)

Table 4.5.
The number and percentage of individual error sources from opposite slope photography in 2002. See text for explanation

Source of error	Error numbers	Relative percentage
Weather (mist, clouds, rain, storm)	94	6.3
Backlight	34	2.3
Manual disturbance from grazing animals	13	0.9
Paddock rotation	12	0.8
Battery failure, camera, timer	12	0.8
Faulty photos (total)	165	11.2
Usable photos (total)	1 324	88.9
Total photos	1 489	100.0

The second-most common cause of error in the method is backlight affecting the exposures (Table 4.5). Depending on the exposure of the site, backlight situations can arise in the early morning or late evening, resulting in the exposures being unusable for an analysis. In some cases, the equipment had to be set up on slopes which themselves were grazed by other herds. Curiosity prompted the animals to 'examine' the equipment, leading to a displacement of the set-up angle of the camera or its falling over, and this accounted for 0.9% of the errors (Table 4.5). In spite of agreements with the local grazing manager, it sometimes occurred that cattle were moved unexpectedly to a different paddock, perhaps in reaction to feed or weather situations. Through this, normally only part of the day was rendered unusable (0.8% error source). Every now and then, battery failure affected the equipment (0.8%). There were no cases of damage to the equipment through grazing animals, ramblers or other reasons during the whole of the investigation period.

The process of data collection by means of opposite slope photography over the course of a year is just as good as 'manual' collection methods, if not superior, with respect to the amount of effort and personnel time. The coverage time per day is certainly greater than can be achieved by manual procedures. Over the whole of the vegetation period, single workers would struggle to collect behavior data up to seventeen hours a day on site. Additionally, the potentially higher error rate, compared to personal observations (there is a total lack of information available here) was found to be within an acceptable limit. Further advantages of opposite slope photography include the relatively little time needed on the site (Table 4.6) and the modest costs of the equipment and supplies. On the other hand, the disadvantages include the dependence on favorable weather and the occasionally poor optical resolutions. In this respect, a manual system may produce better results. A similar situation applies to the exposure interval used here of 30 min. With smaller, more manageable herds at least, manual data collection at shorter intervals could take place. Also, the ethological evaluation potentials are more restricted with snapshot exposures compared to a continuous, direct observation. Additionally, opposite

Table 4.6.
A comparison of personnel input for opposite slope photography and 'manual' collection methods

a Opposite slope photography	Daily work on site	Evaluation per exposure day
Morning – set up equipment and timer	15 min	–
Data collection	–	–
Evenings – take down equipment and timer	15 min	–
Scan photos in PC	–	30–60 min
Transfer visited points to GIS and behavior interpretation	–	60–120 (150) min
b Manual collection	**Daily site work**	**Evaluation per exposure day**
Data collection	10–14 h	–
Transfer visited points to GIS	–	30–60 min

slope photography requires considerably more effort for the evaluation of the data where this has to be analyzed in detail.

Acknowledgments

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4.5
High-Frequency Mesoscale Data Series with the Example of Shepherded Cattle Grazing in Georgia

Andrea Bontjer

4.5.1
Introduction and Outline of the Problem

A significant methodological problem which occurs with the structural description and appraisal of pastureland is the area-wide depiction of the grazing pressure. An indication of the stocking density alone is not suitable with respect to the heterogeneity of livestock effects on a large-scale pasture. Because of the possibility of free choice over where to seek nutrition, overgrazed and undergrazed areas are created which can lead to an intensification or a leveling of the existing locational factors, with a corresponding effect on the vegetation as well as the fauna. This phenomenon occurs with all husbandry variants for livestock kept outdoors but particularly so with large-scale continuous grazing and with shepherded systems. In order to investigate whether specific natural characteristics of the pasture – for example, the vegetation structure and the abundance of selected animal species – have a correlation with the local grazing intensity, it is necessary to obtain a picture of the local grazing pressure which is as accurate as possible.

In many cases, technologically sophisticated procedures such as those described in previous chapters are not available. In the following section, a relatively simple method of collecting information on a 150 ha grazing common with shepherded cattle herding in Georgia (Caucasus) is described. The objective of the investigation was to obtain an area-wide indication of the spatial-temporal visit frequency and to allow conclusions to be drawn about the grazing intensity on the site. Furthermore, the intensities were correlated with the abundance data for various animal species (cf. Sect. 6.4).

4.5.2
Methodology

The pasturing system in the investigation area was analyzed between May and September 1999. For this, both of the herds present (herd 1 with about 80 animals and herd 2 with about 50 animals, young cattle and dairy cows mixed) were each accompanied one or two times each week for the whole day. The cattle were driven onto the pasture each morning at about 8:00 A.M. and left at about 8:00 P.M. They spent the night in stalls in a nearby village.

The results obtained cover a total of 40 observation days, 15 for herd 1 and 25 for herd 2. The lower number for herd 1 is because of a shortage of forage in this summer which meant that they had to be driven to other nearby grassland.

During the systematic registration, the particular location of the cattle (midpoint of the herd) was noted every 15 min on a topographical map (scale 1:5 000), resulting in a total of 1 920 entries for the whole of the observation period. In addition, it was noted for every entry whether the animals were grazing or resting and whether they were

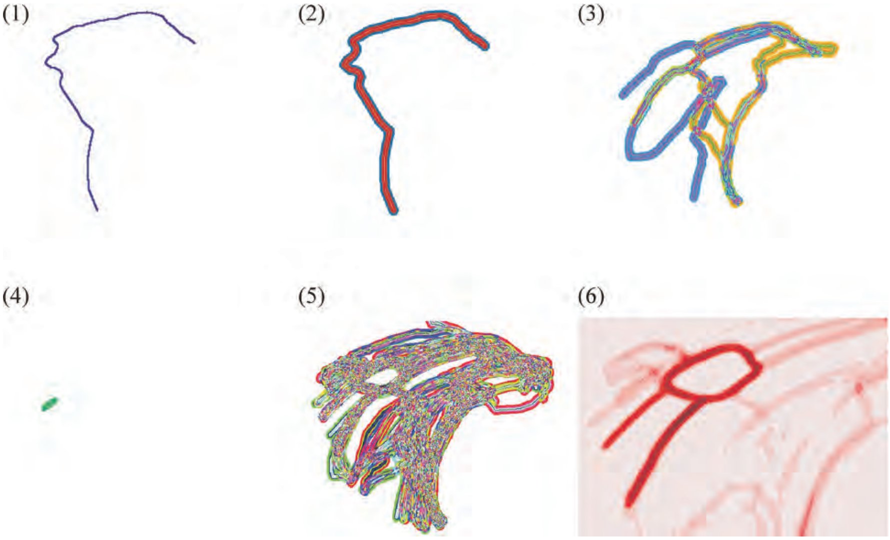

Fig. 4.29. Stages in the evaluation of grazing routes with ArcView (see text for details)

walking or standing still, so that conclusions over the duration of the nutritional intake and grazing or resting places could be drawn.

A further evaluation was carried out with the GIS program ArcView GIS Version 3.1 (Fig. 4.29). After the topographical map had been scanned in, the grazing routes from the site map were entered as lines across the area (stage 1). In the next stage, the lines were extended out from both sides of a distance representing 100 m on a grid (10 × 10 m squares) (stage 2). This corresponds to the space which according to experience, was affected by the activities of the herd in the area. Within this 200 m, various point classes were depicted which corresponded to the various impact effects (the term 'impact' refers here to all life activities of the herd on the pasture which, as well as the grazing of vegetation, includes walking, drinking, excreting etc.). Up to a distance of 10 m both sides of the midline, 10 points were assigned, from 10 to 30 m, 8 points, from 30 to 60 m, 5 points, and from 60 to 100 m, 1 point. Herd 1 received in each case double the points score as it was roughly double the size of herd 2. The allocation of points was based upon observations of the average distribution of cattle inside the herd. Following the arrangement on the grid and the classification, all of the grazing routes were blended together (stages 3 and 5) in that the individual point scores for each grid square were added up. From this, a map was created showing the impact intensities (Fig. 4.30) as areas with different intensities of color (stage 6).

On parts of the area, where the cattle remained a particularly long time, not just in passing, additional points were given according to the number of impact hours. These were multiplied by two and then totaled (stage 4). For rest places, where the cattle did not graze but stayed there for some time, the points were added but not multiplied. Finally, the point numbers were broken into five classes and assigned impact intensities (Table 4.7). In the final stage, the area breakdown of intensity levels was calculated.

Fig. 4.30.
Impact intensities in the investigation area from April until September 1999 through overlaying of all registrations. Total cattle number: 130

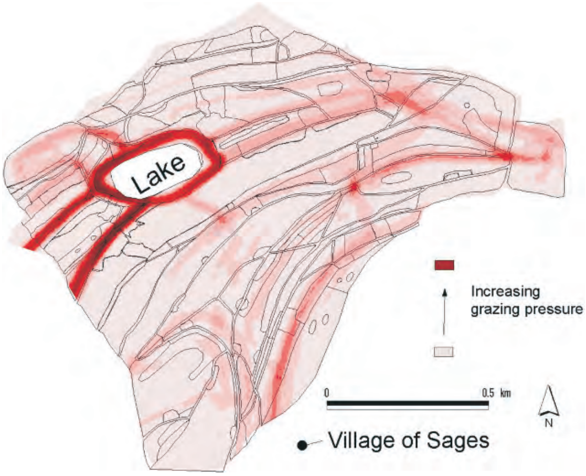

Table 4.7.
Distribution of impact intensities in classes

Calculated points	Impact intensity
> 200	Very high
151 – 200	High
101 – 150	Medium
51 – 100	Low
0 – 50	Very low

4.5.3
Possibilities and Limitations of the Method

Through the relatively high-frequency, standardized mapping of the impact events, it was possible to create a detailed, area-wide picture of the effects of presence during the investigation period. The method of accompanying the herd with exact mapping entries is relatively time-consuming but delivers locationally accurate results with a low expenditure on equipment and at the same time offers the opportunity to observe the animals and therefore collect additional behavior data.

Because the cattle were shepherded and therefore used to the presence of people, the influence of the observer could be ignored. If one or more cows had been fit with a GPS device (cf. Sect. 4.3) the behavior of the rest of the herd would not have been included in the investigation as nothing could have been observed on how the cattle distribute themselves inside the herd.

The high relief of the investigation area and the abundance of site structures (woods, tracks and drove roads) meant that an exact recording of the stopping places of the cattle was not without problem. Any mistake made by a GPS device (up to 30 m with usual devices) would have been a lot greater. On pastures of lower relief, however, this method would quickly reach its limit of applicability. In such areas as

Table 4.8. Comparison of the methods used here with two others used for mapping the behavior and effects of livestock on large-scale pastures (see also Sect. 4.2, 4.3, 4.4)

	Herd accompanying	GPS/data logger	Opposite slope photos
Technical input	Low	Very high	Moderate
Costs	Low	High	Moderate
Applicability	Everywhere, but best on diverse sites	Everywhere	Only in high relief sites with 'opposite slope'
Area coverage	Very good	Very good	Limited (viewing obstacles, weather)
Possible frequency	Moderate	Very high	Very high
Personnel input	Very high	Moderate	Moderate to low (depending on equipment used)
Susceptibility to data gaps through technical defects	Low	Moderate	Moderate
Precision of herd location	High (diverse site) to moderate (unitary site)	High to very high (D-GPS)	High
Disturbance to behavior	Shepherded: low; set stocking: moderate	Low	None
Space/time resolution of behavior	Very high	Low (because of few animals)	Low to moderate
Analytic effort	Moderate	Moderate	High (equalization)

those found on Oeland, it is simpler and more exact to work with remote sensing methods (Table 4.8).

The processing of the data with geographical data systems makes it possible to blend the different observation days and to classify the grazing intensities so that the complex system could be easily represented in a way which was easy to comprehend, without requiring difficult calculations. However, it was unfortunate that with this system, fine nuances could be lost, for example, in the cases when the spread of the herd was over or under the 200 m limit. The inclusion of such details is technically possible but requires considerably more effort than it is worth.

The described method offers the possibility of directly establishing the frequency at which the cattle stopped at specific places and the impact pressure over a long period, and to represent these over the whole area. Most methods described in the literature could only investigate the impact pressures indirectly, for example, through the number of cowpats over an area (Pratt et al. 1986) or the proportion of vegetation grazed short (Van Dyne et al. 1980). In other cases, the activity was only investigated on a sample area of a few square meters (Wallies DeVries et al. 1999).

The counting of cowpats is more suitable for conclusions to be made about stopping frequencies than about grazing intensity, as grazing and excretion mainly take place in different places (cf. Sect. 6.7). For salt marshes grazed by cattle, it was not always possible to find positive correlations between the number of cowpats and the grazing intensity (Looijen and Bakker 1987).

Van den Bos and Bakker (1990) estimated the area-wide grazing intensity from the proportion of vegetation grazed short (<5 cm) and the total herbaceous vegetation. Kaiser and Fischer (1997) estimated the degree of gnawing damage on a sheep-grazed pasture, using grid squares. This is a suitable method for grassland-dominated pastures but would not be feasible in the Georgian pasturelands, which do not have a continuously closed vegetation cover. In addition, it reflects only the life activity 'grazing', leaving other important ecological effects unconsidered (cf. Sect. 4.5).

Another possibility of describing livestock behavior over an area is through habitat use analysis, through which findings can be made about which habitats or vegetation types are preferred by the animals as stopping places and which behavior types can be assigned to these (feeding, resting, urinating and excreting). Putman et al. (1987) describe how such observations were made along transects in the New Forest in England. Through the integration of stopping durations in the observations, an estimate of the impact intensities is possible for the respective habitats. A correlation of the impact intensity in a habitat type with the abundance of a particular animal species would be possible but could not give a direct, precise assignment.

To sum up, the methods described here have, as with all others, their advantages and disadvantages (see Table 4.8). However, with the right conditions, it is a very good compromise with diverging requirements. The technical requirements necessary are comparatively low and the interpretability through suitable behavior observations is high. With a proper evaluation using readily available GIS methods, high-resolution spatial-temporal interpretations of the effects of livestock can be made, even over large areas.

Acknowledgments

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Chapter 5

Microscale Effects

5.1
Grazing-Induced ‘Disturbed Areas’ in Vegetation Creating Microhabitats for Butterflies and Grasshoppers on an Ukrainian Pasture

Henning Elligsen · Harald Plachter · Rolf Satzger

5.1.1
Introduction

Livestock affect areas of pastureland mainly through their feeding activities. Over the course of the year, this has the result of creating a mosaic pattern of microhabitats with different vertical vegetation structures (Bakker et al. 1983; Fuls 1992; Putman et al. 1991; Rambo and Faeth 1999; Wallis de Vries and Daleboudt 1994). However, other manifestations of livestock behavior can have a decisive influence on the structure and composition of such grassland ecosystems (Conradi and Plachter 2001).

‘Controlled’ and engineered pasture variants, such as are now commonly employed in the EU, produce only a very small part of the usual effects on nature that livestock grazing had previously caused through their behavior patterns. In historical times, many pastures were so intensively used that this caused, among other things, damage to the cohesive vegetation cover resulting in more or less extensive soil denudation and erosion. Through this, a wide pattern of varied habitats arose on the pastures (cf. Cornelius and Hofmann 1999).

Through the persistence of old grazing forms in the western part of Ukraine, which occurs in secondary farming occupations during Soviet times (a limited amount of private livestock farming was permitted), and the almost area-wide restitution as a consequence of food supply problems in the last two decades, an exemplary analysis of the effects of ‘historical’ grazing forms can be carried out there. We therefore investigated a large cattle pasture (35 ha) in the East Carpathians (West Ukraine, Busovesko community) in the years 1995 and 2000, with respect to the habitat influences of livestock and their effects on selected invertebrate indicator species and species groups (butterflies and grasshoppers).

5.1.2
Area of Investigation and Methods

The climate in the valley of the Upper Dnister in the Eastern Carpathian foothills is Central European and sub-continental with precipitation of around 800 mm yr^{-1}.

Extensive strips of pastureland extend along the valley flanks, predominantly grazed by herded communal cattle flocks (cf. Tsaryk and Tsaryk 2002). The area of investigation is situated on the slopes near to the village of Busovesko at altitudes between 390 and 580 m a.s.l. It is currently used as cattle pasture but old terraces indicate a former use as fields at least for parts of the pasture. The pasture is part of a communal subsistence system of agriculture without the use of mineral fertilizer and pesticide application. The cattle are herded in communal flocks, including milk cows (each family owns 2 to 3 cattle) between 8:30 A.M. to 12:00 A.M. and 4:00 P.M. to 8:30 P.M.

Between June 01 and September 15, 1995 all butterfly species were registered in grids of $50 \times 50\ m^2$ visually and by net catch (cf. Elligsen et al. 1997). Butterfly individuals of the Wall Brown (*Lasiommata megera*) and the Chestnut Heath (*Coenonympha glycerion*) were captured at intervals of a few days between August 5 and September 15 (second generation), and June 30 and July 29, respectively, categorized according to the state of their wings ("virgin" to "heavily damaged"), individually marked by numbers on the lower side of their back wings, and re-registered in the field afterwards. In total 230 *L. megera* (160 m, 61 f) and 280 *C. glycerion* (165 m, 115 f) were marked. The population sizes of these species were estimated by the share of re-registrations in accordance with Jolly (1965).

On one part of the same pasture (24 ha), the spatial distribution of grasshoppers was analyzed comparatively, independent of the habitat pattern and grazing intensity (Satzger 2002). The actual grazing intensity was estimated based on serial photographs (July 14 until October 4, frequency 20 min and 8:00 A.M. to 7:40 P.M. – cf. Sect. 6.6 in this book) of the area covered by long-grass vegetation in five steps (1–5) and based on the number of cowpats in 93 grid squares of 0.25 ha.

The grasshoppers were caught with a net by 100 sweeps per grid.

5.1.3
Results

5.1.3.1
Butterflies

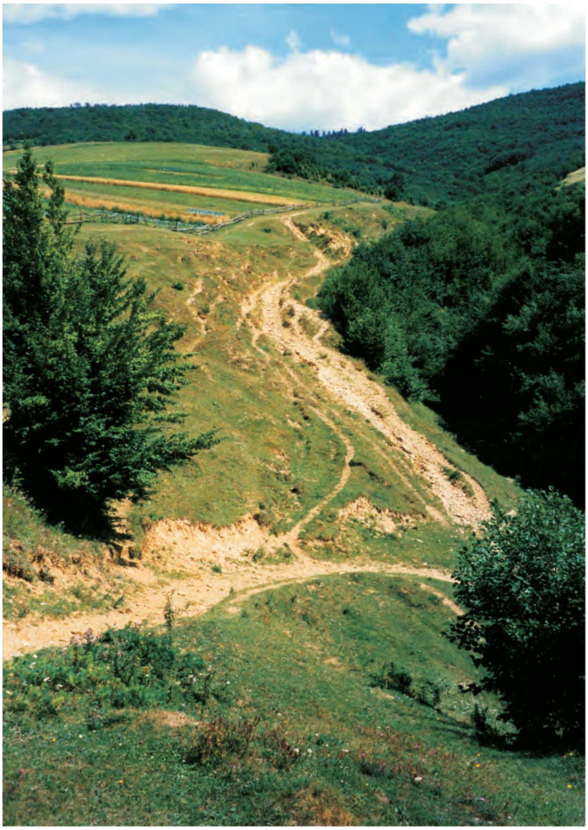
On the 35 ha area, a total of 60 butterfly and nine-spotted moth species were recorded. Included in these were three species which are classified in the German red list (Blab et al. 1984) as 'seriously endangered' (*Iphiclides podalirius*, *Limenitis populi*, *Maculinea arion*) and ten species listed as 'endangered' (*Papilio machaon*, *Apatura iris*, *Limenitis camilla*, *Nymphalis polychloros*, *Nymphalis antiopa*, *Fabriciana niobe*, *Erebia aethiops*, *Coenonympha glycerion*, *Satyrium acaciae*, *Lycaena hippothoe*). A comparison of this type is permissible because of the similar climate and the fact of being in the same bioregion, as well as the lack of an adequate Ukrainian red list (south-east Germany is less than 400 km as the crow flies from the investigation area). The most frequently occurring butterfly species were *Melanargia galathea*, *Aphantopus hyperantus*, *Coenonympha pamphilus* and in particular *Erebia medusa* and *Maniola jurtina*. The latter were – together with the *Pieris* and *Colias* species – the only ones which were regularly registered in short-grass intensively grazed grassland patches.

Small-Area Denudations As a Habitat for the Wall Brown (*Lasiommata megera*)

Out of 230 individually marked butterflies of the Wall Brown, 80 were found again at least once. The rate of recapture of these xerothermophile grassland species (Ebert and Rennwald 1991) amounted to 22% to 44%. We can estimate a maximum local population size of 430 butterflies in the middle of August.

Because of their characteristic 'hill-topping' behavior, this species requires corresponding landmarks (such as eroded edges, tracks, boundary fences around the pasture) In the investigation area, *L. megera* used locations which had mainly arisen from livestock hoof prints and earth slips and were predominantly free of vegetation (broken edges, followed a long way behind by tracks, fences and open rocky areas), which formed striking borderlines between larger, relatively homogenous sections (Fig. 5.1). 94% of all registrations were concentrated here (Fig. 5.2). These areas of concentration are characterized by steep (40–90 degree) slopes and overhanging vegetation (livestock tracks and eroded edges). These were also visited as shade areas and for protection against bad weather. All these continuously used areas were located close to flower-rich grasslands and/or had a good supply of nectar plants preferred by *L. megera* (*Centaurea jacea*, *Leontodon hispidus* and other red to blue-violet flowering plant species). Neighboring areas of thicker grassy-herbaceous vegetation under hedges, bushes and

Fig. 5.1.
Variously structured soil denudations in the south-eastern part of the investigated pastureland (cattle droving tracks): preferred habitat of the Wall Brown (*Lasiommata megera*) (photo: H. Elligsen)



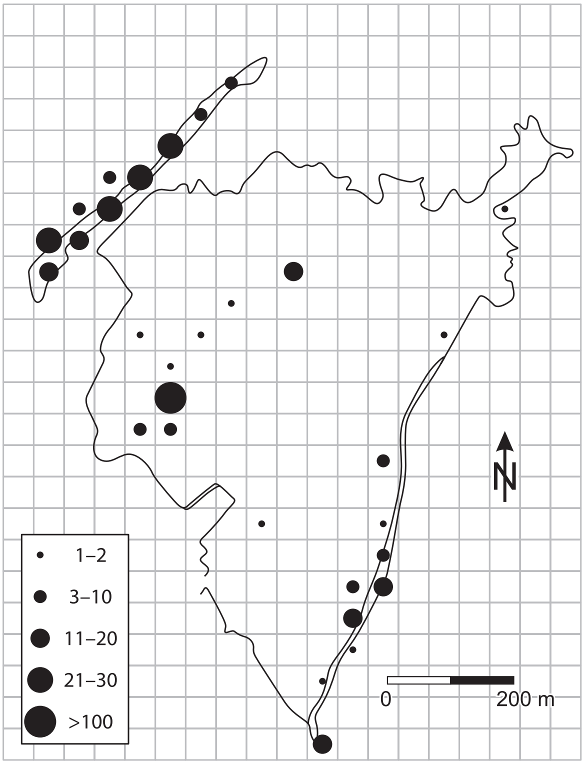


Fig. 5.2.
Distribution of captures of Wall Browns (*Lasiommata megera*) on a large-area cattle pasture in the East Carpathians, 1995, shown in a 50 × 50 m grid system. The density correlates closely with the localized soil denudations (from Elligsen et al. 1997)

along fences serves as a favored place to lay eggs within a narrow spatial network. The highest butterfly densities were found on south to south-west exposed locations with low levels of shade. On north-west exposed denuded ground, animals of this species could only be observed in the afternoon under full sun.

Population Sizes and Habitat Requirements of the Chestnut Heath (*Coenonympha glycerion*)

Out of 280 individuals of the Chestnut Heath which were marked during the flying time, at least 108 were found again (39%). This allows for a calculated population size of 287 to 390 individuals.

In the investigation area, *Coenonympha glycerion* colonized almost exclusively the lightly grazed north-west slopes as well as heavily used areas on the hillside terrace (Fig. 5.3). The species had a clear preference for woodland margins and areas near to woody vegetation (Table 5.1). 91% of the registrations took place near woody species. They preferred highly significant small, south-west exposed grove edges (chi-square (χ^2) test, $p < 0.001$). A third important factor next to woody species proximity and exposure is the spatial structure of the vegetation, which determines the distribution of *C. glycerion*. Highly preferred were the tangled and deteriorated old grass growths of Nardo-Callunetea with an estimated cover of over 95% and an estimated litter proportion between 20–40%. The preferred nectar plants were *Prunella vulgaris* and *Thymus pulegioides*. Intensively grazed, short-grass areas with patchy vegetation were avoided by *C. glycerion*.

Fig. 5.3.
Distribution of *Coenonympha glycerion* in the area of investigation (based on grids of 50 × 50 m). Summation of all registrations in summer and autumn 1995

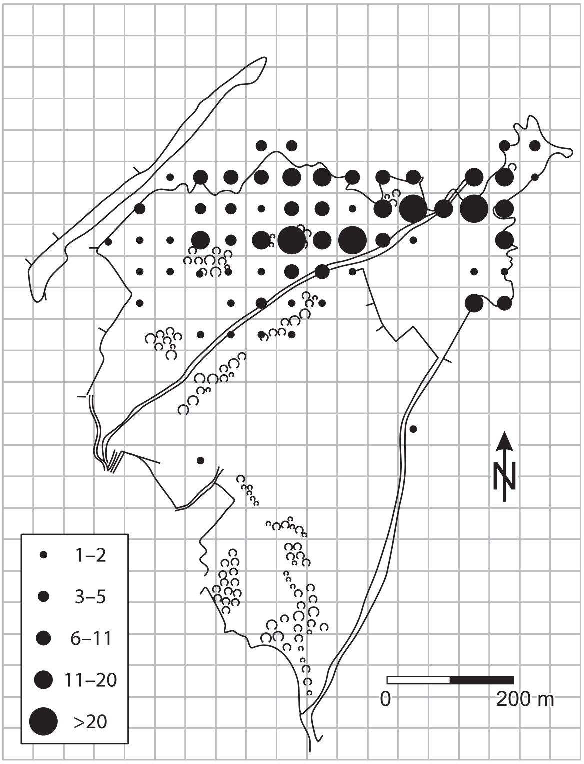


Table 5.1.
Number of registrations of *Coenonympha glycerion* in 1995 in relation to the distance to the next woody habitat

Distance to the next shrub group/forest (m)	Number of registrations
0 – 20	344
21 – 40	81
41 – 60	20
61 – 80	15
81 – 100	2
> 100	2

5.1.3.2
Species Abundance for Grasshoppers Dependent of Grazing Density

Fourteen grasshopper species were found on the 30 grids investigated for the total species set. The average number of grasshopper species on the grid squares is highest with comparatively low occupation densities of less than 0.2 LSU. For areas with a LSU higher than 0.8, the average number of species declines to 3.0. (Spearman's rank correlation $r = -0.5$, $p = 0.004$; Table 5.2). In addition, the Shannon index of diversity declines with higher grazing intensity.

Table 5.2. Average number of grasshopper species per grid (50 × 50 m) for three categories of grazing intensity on a herded cattle pasture near Busovesko in 1999. 1 Livestock unit (LU) = 1 adult head of cattle per hectare; *n* = number of grids, SD = standard deviation (cf. Satzger 2002)

Grazing intensity (LU ha^{-1})	*n* (grids)	Average number of butterfly species	SD	Diversity index *H* (Shannon)
<0.2	15	5.5	1.6	1.25
0.2–0.8	11	3.1	1.0	0.83
>0.8	4	3	1.4	0.81

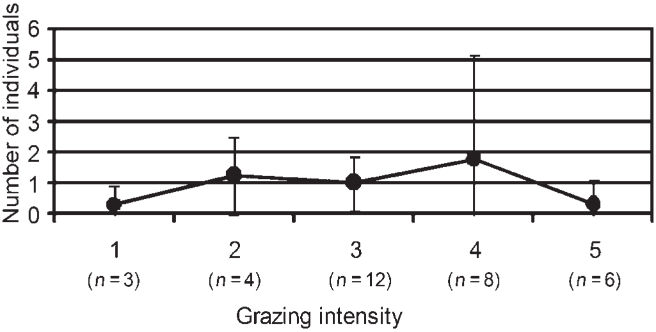


Fig. 5.4. Relationship between grazing intensity and the individual numbers of *Stenobothrus stigmaticus*. For each class of grazing intensity, the average individual number of the species per plot was calculated (*n* = number of plots; the error bar indicates the standard deviation). Findings for 0.25 ha grid squares; *n* = number of grid squares

Distribution and Habitat Use of the Grasshopper *Stenobothrus stigmaticus*

Of the Lesser Mottled Grasshopper (*Stenobothrus stigmaticus*), 34 individuals were detected in 16 of the 93 grid squares (each of 0.25 ha). The species was found mainly on heavily grazed squares with short-grass vegetation (Fig. 5.4). The differences with respect to the abundance of the species and the habitat use are significant (*U*-test, $p = 0.03$). The abundance of the species increased with a finer grain to the habitat structure (low/tall grassy vegetation).

5.1.4
Discussion

Overall species richness of both investigated invertebrate taxons is significantly linked to the local intensity of grazing on the pasture. However, single species show more sophisticated habitat requirements and a spatial composition of different habitats in the close vicinity. *Stenobothrus stigmaticus* prefers heavily grazed and thus short-cut, warm vegetation plots surrounded by tall-grass habitats, *Lasiommata megera* prefers denudated soil areas without vegetation, surrounded by flowered grassland and virgin vegetation near to woods. *Coenonympha glycerion* seems to be much more a forest-border species than a pasture species. Nevertheless it profits from pastures for they generate diverse grassland-forest ecotones at its borders (in contrast to fields) as well as in its interior shrub patches.

Consequently, the ecological effects of livestock are twofold: first, producing specific habitats which are appropriate to certain wild-living species and secondly, generating a spatial-temporal dynamic pattern of habitats which satisfies the complex resource requirements of species within their range of mobility. The effects of technical (mechanical) management and livestock grazing may be comparable on the basis of average figures over the year. However, while technical management impacts affect the whole area similarily within a short range of time, livestock influence divides the pasture into several subunits of subsequent impact, thus generating a highly diverse ephemeral pattern of habitats, which is suitable to many species.

Acknowledgments

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5.2
Livestock Excrement: a Neglected Habitat

Manuel Conradi †

5.2.1
Introduction

In pasture ecosystems, a considerable part of the primary plant production is consumed by the grazing animals. The result of this is that a considerable amount of dung and urine is produced and distributed over the pasture in a way specific to the type of livestock. Dung heaps are important habitats for many specialized animal and plant species. The size of the pasture, and dependent on this, the movement behavior of the grazing animals, can play a considerable role with respect to the spatial and temporal distribution of dung heaps (Conradi and Plachter 2000).

5.2.2
Dung Beetles As Model Organisms

Dung beetles of the genus *Aphodius* are particularly suitable as model organisms for the spatial-temporal quality of these habitats (Hanski 1980a,b; Hirschberger 1998). With their help, it is also possible to investigate immigration and emigration processes. These processes can, among other things, be seen as key factors for the survival of these and similar species (Roslin 2000, 2001).

The genus *Aphodius* is represented in Europe with 80 species (Harde and Severa 1988), in Germany there are 69 species (Köhler and Klausnitzer 1998) and worldwide about 1650 species (Hanski and Cambefort 1991). According to Krell and Fery (1992), *Aphodius* belong to the Lamellicornia suborder and to the Scarabaeidae family. In the moderate latitudes, *Aphodius* is the most significant genus with respect to species numbers in the dung community (Hanski and Cambefort 1991). As well as *Aphodius*, representatives from Diptera, Hydrophilidae, Staphylinidae, Histeridae and Annelida are also found in dung communities.

Dung Beetles

- are generally frequently present (assuming a sufficient supply of dung);
- are of sufficient size with respect to marking and recording;
- under laboratory conditions, are comparatively easy to keep, even over long periods, so experiments can be carried out without restriction;
- are, with few exceptions, largely present in all development stages in the dung resource. This situation makes it possible in the first place to make a directed search for these small and very mobile animals outdoors.

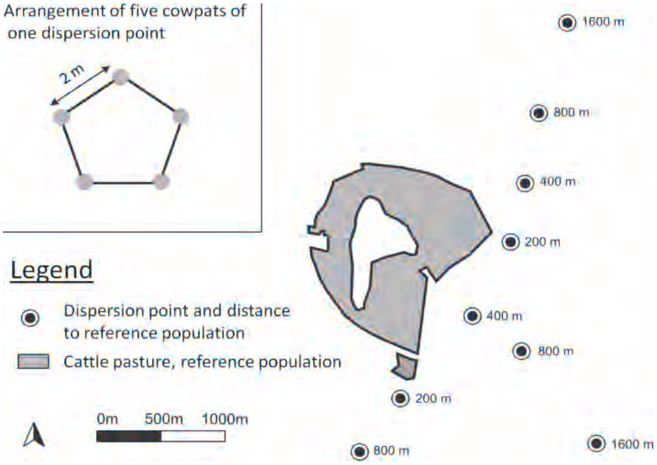
The resource dung is itself advantageous for basic ecological investigations:

- A dung heap can be considered as an ecological unit with defined boundaries.
- Dung heaps have a manageable size and can be comparatively easily manipulated in different ways (introduction of beetles, placing in various macro-habitats etc.).
- The resource dung is irregular with respect to both temporal and spatial distribution and not spread in a predictable way.
- In addition, it is more or less transient (ephemeral habitat). Immigration and emigration events take place therefore comparatively frequently.

5.2.3
Determination of Dispersion Distances

The investigation areas (50°29' N / 10°01' E) is located 24 km to the east of Fulda in the Biosphere Reserve Rhoen, south-east of Ehrenberg at a height of 750–850 m a.s.l. The investigations took place between May and October 1997. The vegetation was predominantly made up of yellow oat-grass (Polygono-Trisetion Br.-Bl. et Tx. 43 ex Marsch. 47 n. inv. Tx. et Prsg. 51) and the species-poor mat-grass (Nardetalia strictae Oberd. ex Prsg. 49). In total, 10 733 beetles from 13 species were caught and classified. In order to determine the scale of the dispersion distances, cattle dung (cowpats) was spread in 200 m, 400 m, 800 m and 1 600 m distances from a reference population to the east of an adjoining Bavarian part of the Rhoen, outside of grazed areas (Fig. 5.5). A unit (in the following referred to as a dispersion point) consisted of in each case 1.5 kg (fresh weight) cowpat which was collected after an exposure time of five days. The beetles were removed from the dung with the help of the flotation method (Hanski and Koskela 1977; Moore 1954; Koskela 1972; Skidmore 1991) and then analyzed. The cowpats in a unit were arranged in the form of a pentagon with an edge length of two meters (Fig. 5.5). Because the area between the dispersion points and the reference population was not grazed with cattle, the only cattle excrement present was that which was placed there, and therefore it can be assumed that beetles specializing in cow dung which were found in the cowpats had at least traveled the distance between the reference population and

Fig. 5.5.
Position and distances of dispersion points in relation to nearest reference population


Arrangement of five cowpats of one dispersion point
2 m
Legend
Dispersion point and distance to reference population
Cattle pasture, reference population
0m 500m 1000m
1600 m
800 m
400 m
200 m
400 m
800 m
200 m
800 m
1600 m

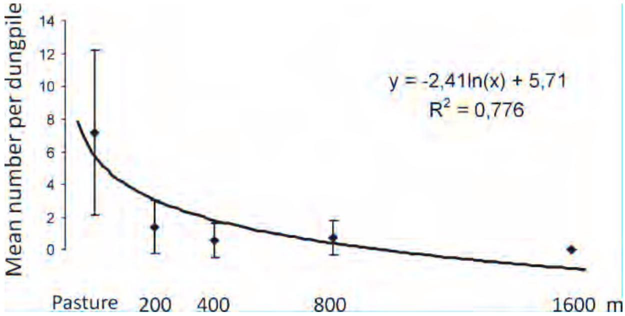


Fig. 5.6. Decrease in population densities of *A. fossor* ($n = 67$ insects) with increasing distance from the cattle pasture, in the first experiment in May. The average value of insects found per cowpat and the standard deviation is shown. Additionally, a trend line is indicated describing the relationship. The function equation and the coefficient of determination can be ascertained from the figure. Sample numbers: pasture: $n = 5$ cowpats; 200-m distance: $n = 10$; 400 m: $n = 10$; 800 m: $n = 15$; 1600 m: $n = 10$

these deposits. For the distance of 800 m, an additional dispersion point was placed so that the investigation included nine dispersion units and the reference unit on the cattle pasture (five cowpats).

On the cattle pasture south-east of Ehrenberg (source population), the average value for the insects per cowpat was 7.2 for *A. fossor* (Fig. 5.6). In the cowpats placed to the east of this, there were significantly less numbers of beetles (single factor ANOVA; Bonferroni post hoc test $p < 0.05$). The individual numbers of beetles found decreased with the distance. The decrease can be described using a logarithmic curve with the function $y = -2.74 \ln(x) + 5.71$. The quality with which the curve describes the relationship can be classed as good ($R^2 = 0.776$).

In the cowpats which were placed 1600 m from the pasture, *A. fossor* could not be found. The dispersion movements of *A. fossor* are therefore limited by the distance.

5.2.4
Emigration and Immigration

This part of the investigation was carried out on an average-sized sheep pasture (12 ha) in the Thuringian part of the Rhoen which was grazed three times a year for 8–10 days by sheep flocks ranging from 600–1000 heads, according to the season. For an experimental run, about 20 kg of fresh, non-colonized sheep dung was required, and this was distributed in 125 g portions.

A specific experimental design was developed for the quantitative determination of population-ecological partial processes, consisting of three test rows each with fifty sheep dunghills: a pitfall trap row ('pitfalls'), a row with insects from the beginning of succession placed in the dunghills ('row with earlier colonization') and a row with untreated dunghills ('reference row'). From each test row of fifty units, ten were collected and sorted after 1, 2, 4, 6 and 9 days in order to document the changes during the course of succession (Fig. 5.7).

With the help of the reference row (row 3 in Fig. 5.7) the changes to average densities of individuals per species in each dunghill could be measured over a nine-day

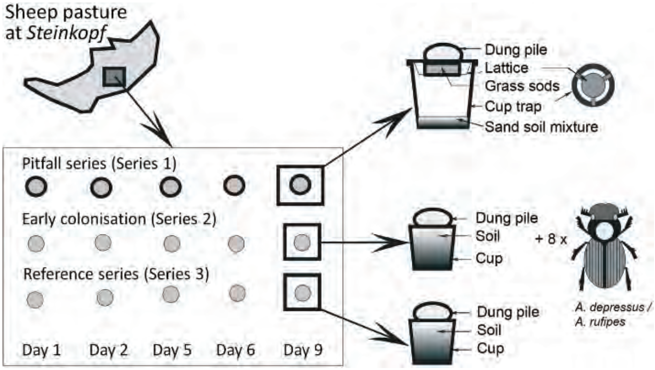


Fig. 5.7.
Experimental design. The comparison between the pitfalls, the rows with earlier colonization and the reference row makes possible qualitative statements on the partial processes occurring during the course of colonization. Ten units from each row (represented above with circles) were collected on days 1, 2, 4, 6 and 9 of the succession

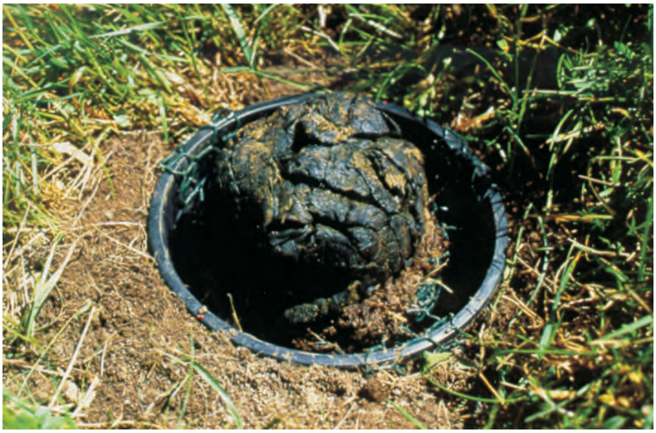


Fig. 5.8.
Pitfall trap with dung bait. The grid construction and the piece of turf placed around it can be seen (photo: M. Conradi)

period of succession. In the following, these are denoted as ‘actual colonization process’, or in short, ‘colonization process’. A unit from the reference row consisted of a cup (opening diameter: 7 cm, height: 7 cm) which was filled with soil up to the rim and set in the soil to the same level. A dunghill weighing 125 g was laid on top of it. In this way, the dunghill reflects the natural levels of densities and any changes to these.

In the pitfall row, (row 1 in Fig. 5.7 and Fig. 5.8), a cup with a height of 13 cm and diameter of 14 cm (changed in accordance with Hanski 1980b,c). In the opening of each cup, a grid construction was suspended, on which a dung bait (125 g) was placed. Between the grid and the bait, a 3 cm high piece of turf was added to protect the dung from drying out. The base of the cup had holes in it to allow rain water to exit quickly and was covered with synthetic gauze (mesh size 1 mm) to prevent beetles escaping into the soil. Each trap was filled with a layer of sand-soil mix about 2–3 cm thick so that the base was well covered.

The trap functions through the behavior of the beetles, which are attracted by the smell and land by the side of the dunghill in order to approach it from the side. On the way to the dung, the beetles fall into the cup, where they bury themselves in the sand-soil mix. With this trap construction, therefore (cf. Hanski 1980b,c), *all* beetles attracted to the dung can be caught, including those which in a normal exposure would have left the dunghill after a relatively short inspection and grubbing time. This pitfall trap therefore measures the total immigration (Hanski 1980b).

The row with early colonization was constructed exactly as the reference row, except that in the fresh dunghill, eight marked beetles were placed at the start of the experiment. The purpose of this experimental row was to investigate the effects of earlier immigration on the course of further colonization.

The immigration experiment was repeated a total of four times (May, July, August and September 1997).

The colonization process (reference row) and the immigration (pitfalls) were measured directly. Emigration (*E*) could only be indirectly measured (Fig. 5.9). It is calculated from the difference between immigration (*I*) in the interval t_i to t_{i+1} and the change to the actual population density (Δ) during this interval. The immigration level during a day was determined with the help of the pitfall trap and equals the number of beetles caught in this time. The actual colonization process was measured using the reference row. Through the comparison of the population density on day t_{i+1} with the level on the previous day t_i, the changes (positive or negative balance) could be recorded.

If there is a net increase in the density of individuals in the dunghill (positive balance compared to the previous day), this value must be subtracted from the immigration figure in order to attain the total emigration, because some of the incoming beetles remain in the dung. The insects which arrive at the dunghill without increasing the population density must necessarily have emigrated. On the other hand, if a net decrease is found (negative balance compared to the previous day), this value must be calculated with the immigration total. Towards the end of the succession, when there is no more immigration, this value gives the emigration total directly (see Fig. 5.9).

In May, the number of *Aphodius depressus* individuals which immigrated on the first day (on average, 8.8 per dunghill) was almost identical to the number of beetles which were found in the dunghills of the reference row. This means that almost all arriving individuals decided to remain in the first dunghill that they approached. From the second to the fourth day, further beetles arrived (on the second day, averaging 2.4 individuals per dunghill). Despite this continuing immigration, the number of beetles in the dung decreased steadily from the first day, that is, emigration exceeded immigration in this time period. The colonization of the dunghill through imagos of *A. depressus* ended between the seventh and ninth day (Fig. 5.10).

Because of the poor weather conditions in July 1997, dung beetles were not very active. The average number of immigrated beetles during the first and second days clearly exceeded the numbers in the reference row (Fig. 5.11). However, because of the high variation of individual numbers in the dunghills, the difference was not significant (Mann-Whitney *U*-test; day 1: $p = 0.13$ and day 2: $p = 0.25$). The average popula-

$$\boxed{E = I_{I(t_i,t_{i+1})} - \Delta N(t_i) - N(t_{1+1})}$$

Fig. 5.9. Determination of emigration *E*; I = number of immigrants caught in the pitfall trap in the interval (t_i, t_{i+1}) and $N(t_i)$ or $N(t_{i+1})$ = number of beetles on the day ti or t_{i+1} in the reference row. With a net increase in the population density, the difference Δ is subtracted from the value for immigration, and is added for a net decrease

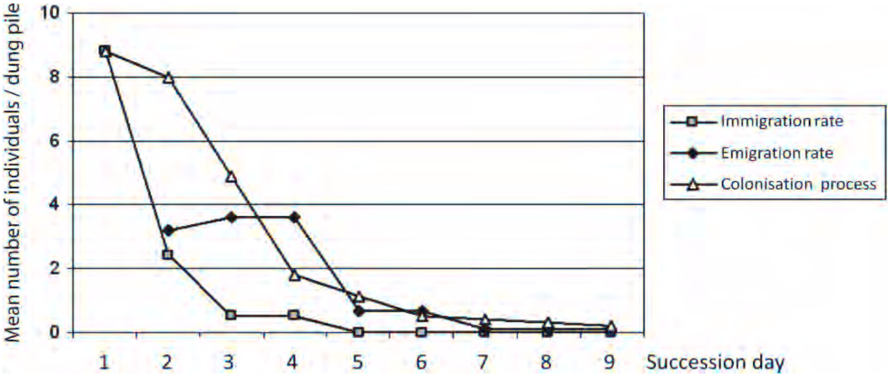


Fig. 5.10. Colonization process and sub-processes in the colonization of *A. depressus* in May. Immigration takes place mainly in the first two succession days. Emigration starts on the second day and is relatively high until the fourth day

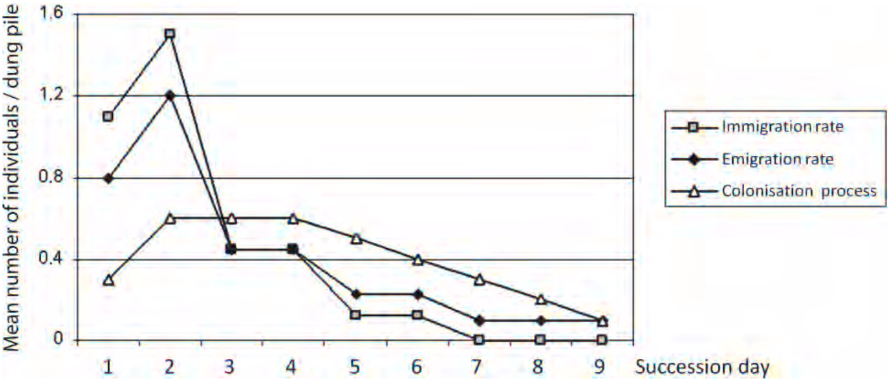


Fig. 5.11. Colonization process and partial processes in the colonization of *A. rufipes* in July. Immigration and emigration processes take place mainly in the first two succession days

tion density of *A. rufipes* amounted to 0.3 individuals per dunghill on the first day and 0.6 on the second. Also on the fourth day, 0.6 beetles per dunghill were counted, and the data indicate a somewhat higher density on the third day. After the fourth day, the average number of beetles in the dung decreased as the immigration continued until the sixth day. On the ninth day, there were only on average 0.1 individuals of *A. rufipes* per dunghill present. At this point in time, the colonization can be considered to be over.

In August, the difference between immigration and actual colonization was particularly noticeable (Fig. 5.12). On the first two days of the experiment, immigration was significantly higher than the number of beetles in the dung (Mann-Whitney *U*-test; both days: $p < 0.05$). On the first day, five times as many *A. rufipes* individuals arrived at the dung and on the second day, seven times as many, as actually became established. From the third day, a net decrease in the density of individuals was found. On the ninth day, the colonization of the dunghill by *A. rufipes* was virtually over (0.17 individuals per dunghill).

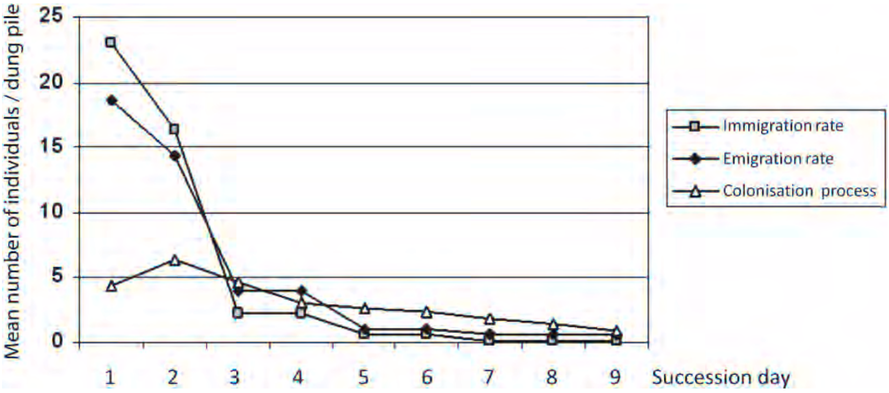


Fig. 5.12. Colonization process and partial processes in the colonization of *A. rufipes* in August. Immigration and emigration processes take place mainly in the first two succession days

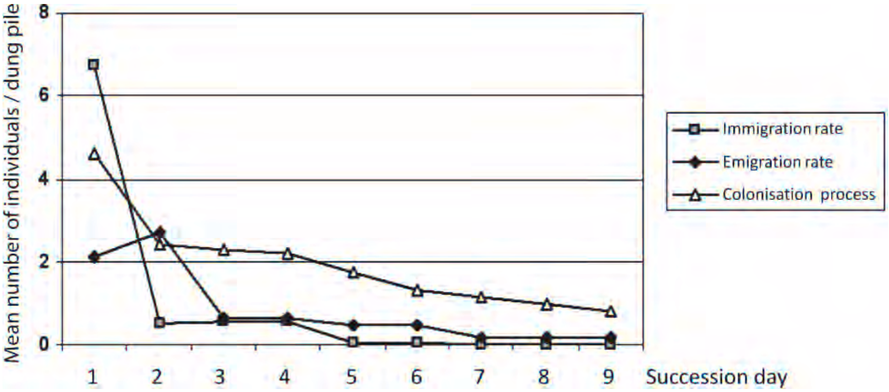


Fig. 5.13. Colonization process and partial processes in the colonization of *A. rufipes* in September. Immigration and emigration processes take place mainly in the first two succession days

In September, an average of 6.7 *A. rufipes* individuals flew to a dunghill on the first day of exposure (Fig. 5.13). About two-thirds (4.6 individuals per dunghill) could also be found in the reference row and the remaining third left the dunghill on the same day. This difference is significant (Mann-Whitney *U*-test; $p < 0.05$). Already by the second day, there were only about half the number of beetles found the previous day in the dung. The colonization density sank continuously in the course of the succession. Until the sixth day, arriving beetles could be registered and until the fourth, the extent of immigration was appreciable (between the third and fourth days, 17% of the first succession day immigrated). On the ninth day, there were still on average 0.8 individuals of *A. rufipes* in the dunghills. This is a somewhat higher value than in the other experimental runs. The fact that at the end of the experiment in September, there were more individuals of *A. rufipes* in the dung indicates a lengthening of the residence time over the year.

The pattern of colonization is characterized mainly through the following phenomena: After exposure of the dung, there is immediately a period of lively immigration, but only a proportion of the beetles remain until the next day. This unequal relationship between immigrating beetles and those staying for a longer period in the dung was characteristic of the first two succession days. The immigration process continued also during the following day. Sometimes, arriving beetles could even be registered up to the sixth day. Occasionally, emigration numbers exceeded those for immigration after the second day so that the density continuously declined. After nine days, *Aphodius* could hardly be found in the dung. The colonization of the dung by imagos was therefore limited to a very narrow window of time. With only a few exceptions, larvae only appeared after colonization of the dunghill by imagos had finished. The development stages were therefore normally separated over time.

It is therefore important to appreciate that the colonization process of a dunghill in the first two days is accompanied by a distinctive dynamic of immigrating and emigrating beetles. The resulting colonization process is a dynamic balance between emigration and immigration, which, in comparison to this sub-process, undergoes only relatively small changes.

5.2.5
The Effects of Earlier Colonization on the Further Colonization Process

Through a comparison between the row with earlier colonization and the reference row, the effects of immigrating individuals at the beginning of succession on the further course of colonization of the dunghill can be determined.

The results of the three experimental runs with *A. rufipes* (July, August and September) make it clear that in the first two days of succession, the row with earlier colonization was visited by a higher number of individuals than the reference row (Fig. 5.14). Although the differences were not significant, including in the case of *A. rufipes* (Mann-Whitney *U*-test: day 1: $p = 0.10$ and day 2: $p = 0.08$), the hypothesis that *A. rufipes* has an attracting effect on fellow species in the first two days of succession is supported by a consideration of average value differences in both experimental rows. This assumption was tested in a specific experiment under laboratory conditions.

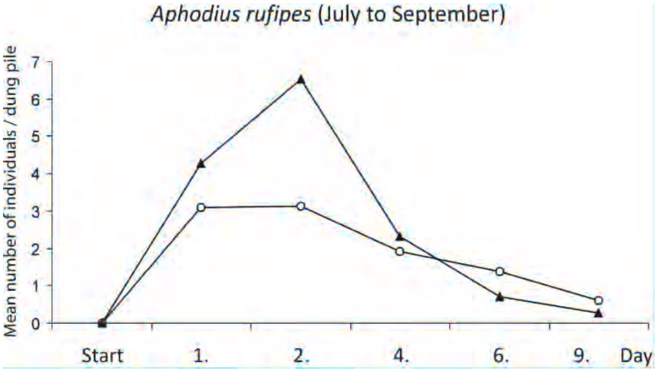


Fig. 5.14.
The effects of earlier colonization on the further colonization process. The average number of individuals per dunghill is shown against the succession duration. For *A. rufipes*, there are average value differences. The row with earlier colonization is indicated with a black triangle (▲, $n = 422$ individuals) and the reference row is indicated with a circle (○, $n = 304$ individuals)

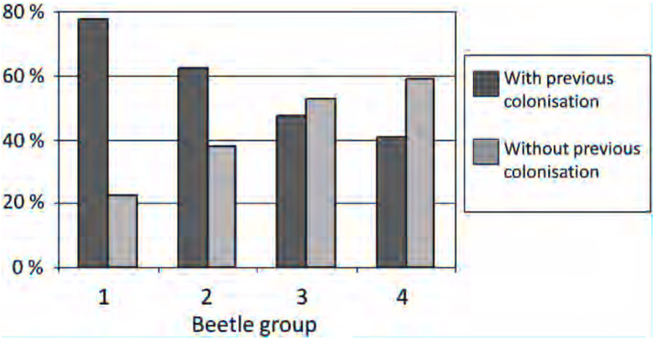


Fig. 5.15.
The effects of conspecific presence on the colonization process of *A. rufipes*. The diagram shows the counter-development of colonization behavior for *A. rufipes* ($n = 372$ individuals). Initially, the dunghills with existing colonization were preferred. Beyond a density of more than 10 individuals had been reached, the preference swung in favor of uncolonized dunghills

A colonized and an uncolonized dunghill were placed in a plastic bowl and 12 beetles were successively added to these in three groups. Each group of beetles was identified with differently colored markings. A clear reaction to earlier colonists of the same species could be found following 31 experimental runs with *A. rufipes* (Fig. 5.15).

The first three introduced beetles (group 1, beetles 1–3) clearly favored the dunghill with pre-colonization by conspecifics. 77% chose the colonized and only 23% the uncolonized dunghill. This difference is significant (Mann-Withney *U*-test, $p < 0.05$).

Also, the beetle group subsequently introduced (group 2, beetles 4–6) had a significant preference for the colonized dunghills (Mann-Whitney *U*-test, $p < 0.05$). The ratio between choice of the dung with pre-colonization and choice of the uncolonized dung was 62 to 38.

Group 3 (beetles 7–9) spread themselves equally over both dunghills on offer. Here, 47% chose dunghills colonized at the start of the experiment and 53% chose the uncolonized dung (Mann-Whitney *U*-test, $p > 0.05$).

In group 4 (10 or more introduced beetles), the ratio turned in favor of dunghills which were not colonized or only partially so. This result is significant (Mann-Whitney *U*-test, $p < 0.05$). 59% chose the dunghill with no prior colonization, while only 41% chose the dunghill with conspecifics.

5.2.6
Conclusions

The dispersion ability of *Aphodius fossor* is limited, despite the obviously good individual mobility. This observation agrees with investigations regarding the effects of fragmentation of dung beetle species in Central Amazonia. (Andresen 2003; Klein 1989). The spatial distribution of pastures, which make dunghills available, are therefore significant factors in the habitat quality and connectedness of sub-populations of insects which occupy dung.

The colonization pattern of *Aphodius rufipes* is determined through immigration and emigration processes. After 9 days, the colonization process is finished and the beetles have left the dunghill.

The pattern of colonization can be divided into two phases: (1) adult beetles feed on organic material and micro-organisms which develop in the fluid components. The intake of nutrients, determined by the arrangement of the mouth parts, is only possible in fresh dunghills. (2) Although the quality of the nutrition reduced with the age of the dung, several beetles remain in the dunghill. The reason for this is to reproduce. The females test the suitability of the dunghill intensively for the development of larvae before laying their eggs.

An explanation for the established intraspecific aggregation of *A. rufipes* within the first two days could be an improvement in the suitability of the habitat and mate-finding (see also Palestrini et al. 1998).

For the survival of dung beetles at the population level, the availability of dunghills and the distribution of these in the landscape context plays an important role. Spatially connected pastureland could therefore assist dung beetles and other invertebrates adapted to dung.

Acknowledgments

My thanks go especially to Dr. S. Brunzel (Marburg University) for the engaged support, Dr. P. Hirschberger (Humboldt University Berlin) for the interesting discussions on the subject of dung beetle ecology and Dr. U. Schaffrath (Kassel) for the assistance with the identification of *Aphodius*. I also like to thank the Hessian Management of the Rhoen Biosphere Reserve for their support.

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5.3

The Effects of Cattle Browsing on Woody Vegetation in Large-Scale Pastures of the Thuringian Rhoen and the South Black Forest

Michael Hauck · Almut Popp

5.3.1

Introduction

One of the most important functions of livestock as an alternative management instrument for open land ecosystems is their effects on the development of woody succession. Until now, goats have been ascribed a high impact, sheep a medium and cattle a quite small one. The latter observation appears initially plausible, based on the feed preferences and the specific form of nutritional intake (grasses with a significant involvement of the tongue). A robust investigation of this assumption, however, has until now not been available. Also, the distribution and appearance of woods on many continuous cattle pastures leads one to assume that here too, the impacts of livestock may be greater than previously accepted.

5.3.2

Methodology

The impacts of cattle on woody vegetation may be manifested on individual tree species through tree contact, that is, through direct browsing or through grooming behavior (rubbing for skin care causing possible damage to bark or the breaking off of branches). In the first year of our investigations (2001), the focus of the observations was on the impacts that cattle have on tree growth. At the start of our investigations, a mapping was carried out covering all pastures in the Thuringian Rhoen and the South Black Forest (Rhoen: set stocking *Hemschenberg* = *HB*), *Lichtenau* = *LA*), *Rotenhauck* = *RH* and *Ellenbogen* = *EB* as well as the adjacent rotational pasture *Rotenhauck-U* = *RHU* and *Ellenbogen-U* = *EBU*; Black Forest: *south slope* = *SS*, *west slope* = *WS*). Using a combination of the methods 'scan sampling' and 'continuous sampling' (for more details about the methods, see Sect. 6.1), browsing events and grooming behavior activities with woods were continuously recorded for all cattle in the herd at ten-minute intervals, each scan being one minute long. For 'tree/bush contact', the number of events involving browsing and grooming behavior per equal unit of time were recorded (100% = all contacts with trees/bushes during the whole observation period). The woody species were separately recorded and classified into species types ('woodland species') and also according to their growth form and communities ('woodland formations', Table 5.3).

The areas of the woody vegetation visited by the cattle were recorded in order to establish particular preferences. The species data was entered into geo-referenced aerial photographs and then the areas were read out area by area from the GIS program ArcView. In the South Black Forest, the pastures were continually visited and the growths of woody species there were individually counted, with estimates made for the thicker growths. For all pastures, the proportion of growths was calculated. The species types were classified according to the actual extent of browsing which had developed over years of pasturing. The growth forms of the trees were separated into three grades of

Table 5.3.
Defined wood formations

Growth forms	Characterisation of woody species formations
Single tree	Free-standing single tree or bush
Hedge	Hedge or copse, either exclusively of bushes or with several trees in the center which are not accessible to the cattle
Tree hedge	Row of trees without understory, in part, sporadic bushes, no obstacles to access to the trees
Woodland edge	Edge of woodland formation with minimum 10 m diameter
Wood	Wood formation with minimum 10 m diameter, mainly trees

Table 5.4.
Classification of species parameters

Browsing grade	Effect on plant structure
1. Slightly browsed	No or slight browsing, individual leaves missing
2. Moderately browsed	Moderate browsing, growth slightly affected, branches missing, gaps in foliage
3. Severely browsed	Strong to severe browsing, leaves completely absent within reachable height for cattle, shape completely modified

browsing (slight, moderate and severe – Table 5.4). Comparisons between the browsing preferences for different species were carried out with the selectivity index *E*; preference sites visited and entered were determined with the preference index *P* (cf. Sect. 6.1).

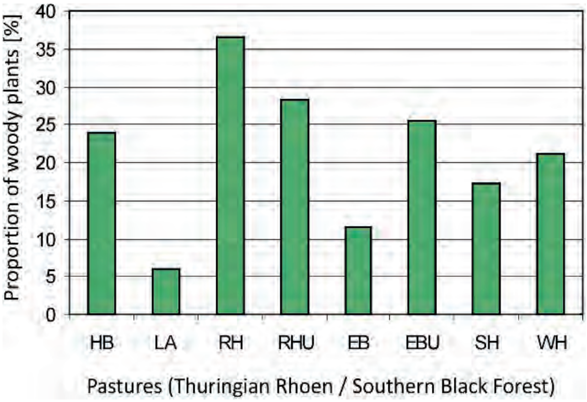
5.3.3
Results

Species Utilization

The woody species, consisting of formations of single plants, hedges, tree hedges, woodland edges and woods, were located inside the pasture fencing and were therefore accessible to the cattle.

The growths of woody vegetation covered an area of between 5–36% of the individual pastures (Fig. 5.16). The pasture *RH* had the greatest area of growth with 36.5% and the pasture *LA* had the smallest, with 5.9% (2001) and 5.3% (2002/2003). In comparison to the overall behavior of the cattle, browsing on woody vegetation (gnawing leaves and branches) and grooming behavior (rubbing) took up only a very small proportion as these events are of short duration. Within the total observation time for the grazing period 2001, there were 737 recordings of woody vegetation contacts in the Thuringian Rhoen (648 browsing and 89 grooming behavior events) and in the South Black Forest, 177 woody vegetation contacts (143 browsing and 34 grooming behavior events). In both cases, the number of browsing events was considerably higher than the grooming events.

Fig. 5.16.
Area proportion of woody vegetation on the pastures of the Thuringian Rhoen and South Black Forest, 2001



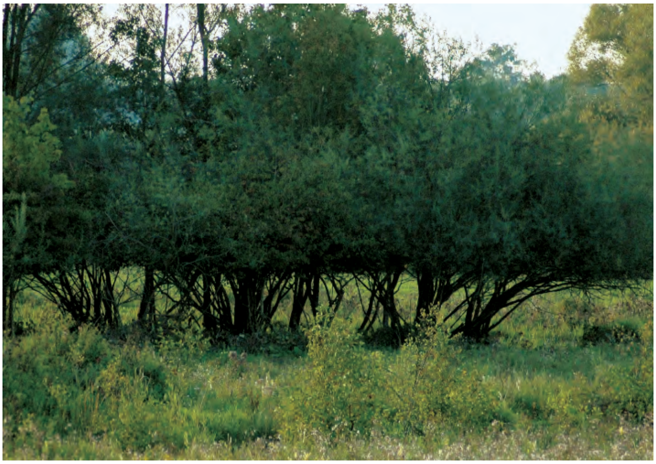


Fig. 5.17.
Tree hedge, cropped by browsing. Cattle pasture at Ellenbogen, 2001 (photo: M. Hauck)

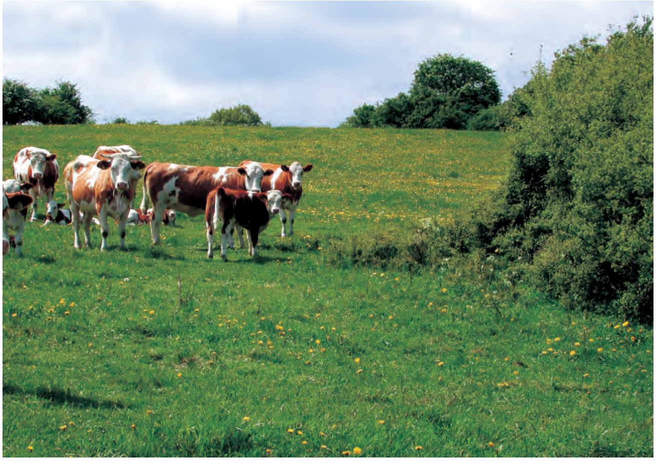


Fig. 5.18.
'Browsing hollow' in hawthorn (*Crataegus* sp.) caused by cattle on the pasture at Hemschenberg, 2002 (photo: H. Plachter)

Effects on Woody Vegetation

It is clear that cattle browsing has a quite considerable impact on the woody vegetation growing on pastureland (Figs. 5.17 and 5.18), despite the infrequence or low proportion of time spent on this. A significant reason for this may be that cattle on large-scale pastures orientate themselves mainly on growths of woody species for their daily movements (Fig. 5.19). For a considerable proportion of the day, they remain close to such growths.

It is also clear that on the investigated pastures, plant species capable of wide dispersion, such as *Prunus* and *Crataegus*, occur often in a very compact form, though isolated from the next growth of bushes. They are frequently surrounded by a ring of

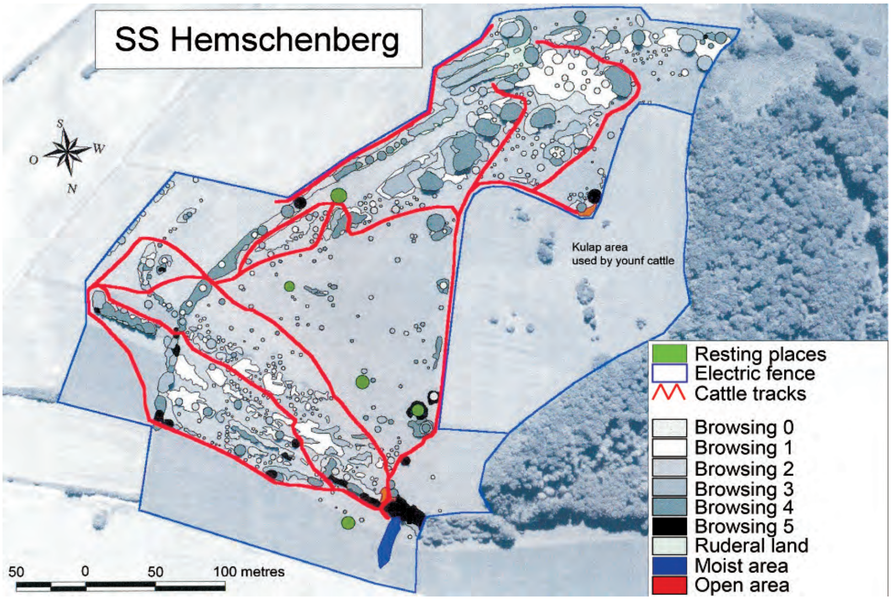


Fig. 5.19. Cattle routes and browsing effects in 6 classifications on the cattle pasture Hemschenberg, 2001

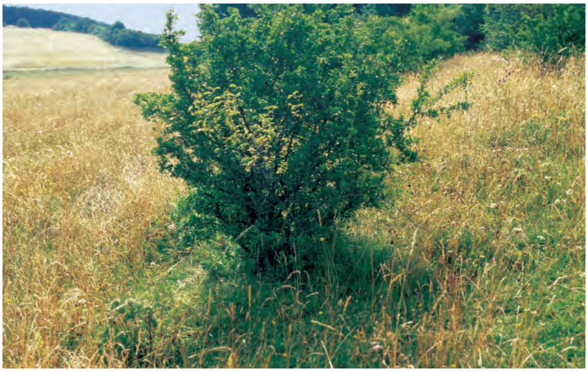


Fig. 5.20.
Crataegus laevigata with 'cropped ring', recognizable by the more intensive green coloration, on a cattle pasture at Hemschenberg, 2001 (photo: M. Hauck)

severely cropped herbaceous-grassy vegetation (Fig. 5.20). On 60 transects running perpendicular from the center of the particular bush, there was a significantly lower vegetation height for the first 2–3 m (Fig. 5.21). Comparable effects were also found along hedges (Fig. 5.22).

Because of their size and strength, cattle are capable of breaking off and damaging branches and smaller stems measuring up to several centimeters in diameter. In some

Fig. 5.21. Maximum, median and minimum heights for herbaceous-grassy vegetation along 10 m transects perpendicular to the center of individual bushes on the set stocking cattle pasture Hemschenberg, summer 2001; *N* = 60

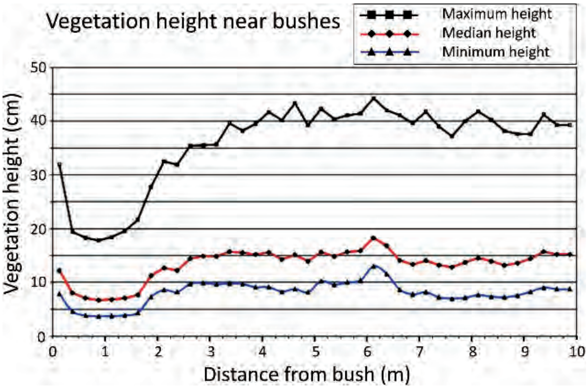
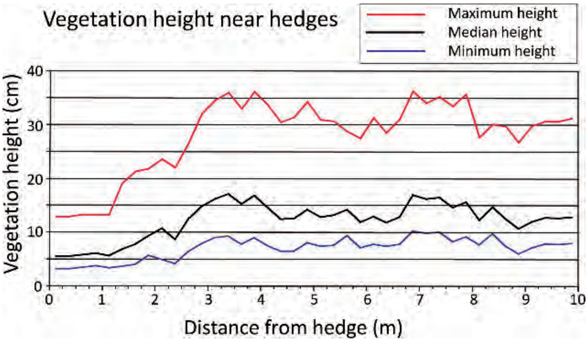


Fig. 5.22. Maximum, median and minimum heights for herbaceous-grassy vegetation along 10 m transects perpendicular to the edge of a linear hedge on the set stocking cattle pasture Hemschenberg, summer 2001; *N* = 30



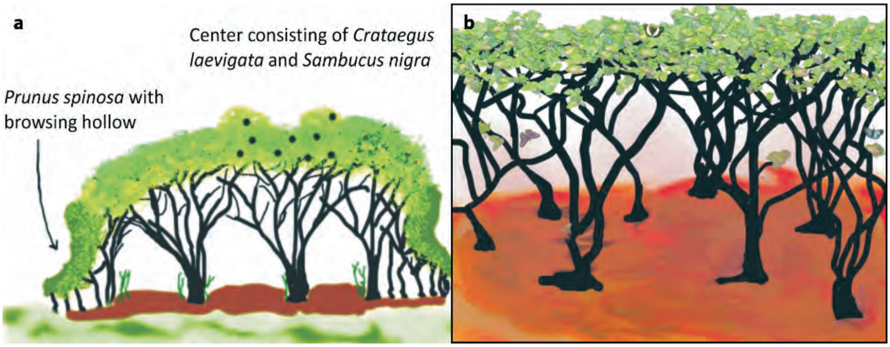

a
Center consisting of *Crataegus laevigata* and *Sambucus nigra*
Prunus spinosa with browsing hollow
b

Fig. 5.23. a Representation of **a** hedge shelter formed by grazing and **b** the interior, 5–6 m high parts of the Thuringian pastures, this was a result of the need for shaded areas during the summer and perhaps also a wind shelter with the formation of regular bowers, created by the cattle themselves to serve as a daily refuge. Inside, they consist of bushes and low-growing trees (*Crataegus* sp., *Rosa canina*, *Sambucus nigra*, *Salix caprea*, *Corylus avellana*). At low levels, there is a lack of any vegetation, even dead branches. These have clearly been removed by the cattle, along with all the leaves. The surrounding border consists frequently of a ring of blackthorn (*Prunus spinosa*), reaching a thickness of 1–2 m and with only a few breaks in it which are obviously kept open by the normal habits of the cattle. In bowers regularly visited by the cattle, there is virtually no herbaceous layer and absolutely no growth of woody species. These forms appear to need long periods of time for their development such as can be found inside older groups of trees or bushes.

The fact that the structures described here are actually the result of active cattle influences can be seen from an abandoned bower on the pasture at Hemschenberg: the blackthorn ring had closed up. The inside was still accessible and elder and hawthorn side-branches were absent, as usual. In contrast to used bowers, the herbaceous layer had changed dramatically. With a total coverage of 40–60%, the layer was rich with *Galium odoratum*, *Urtica dioica*, *Geranium robertianum*, *Geum urbanum*, *Senecio ovatus*, *Torilis japonica*, *Anthriscus sylvestris*, *Milium effusum*, *Dactylis polygama* and *Mycelis muralis*. There were three young beech trees (*Fagus sylvatica*) and five field maple (*Acer campestre*) seedlings.

Similar woodland structures, also obviously created by cattle, are large, easily accessible 'hawthorn woods' which resemble Mediterranean macchie or Pannonian shibliak. They achieved a height of 6 m on the Hemschenberg pasture and consisted throughout of very old individuals, in which the leafed crown is restricted to the upper fifth section (Fig. 5.23b).

Formations of Woody Vegetation

According to the time division of the ethological investigation on the pastures of the Thuringian Rhoen, the cattle mainly visited tree hedges out of all the available woody vegetation formations. A comparison of browsing and grooming events shows that the latter has only minor significance for the impacts on trees and bushes. If browsing and grooming behavior are analyzed separately (browsing = 100%, grooming = 100%), the breakdown for all impacts on tree hedges is 48.1% for browsing and 61.8% for grooming behavior. The effects of both browsing and grooming behavior on tree hedges were apparent to a significant extent (both $p < 0.001$, G-test, Table 5.5, 5.6).

For bush hedges, browsing made up 18.2% of recorded events and there was significantly low grooming behavior ($p < 0.05$) of 10.1%. The individual trees and bushes on the pastures of the Thuringian Rhoen consisted mainly of *Crataegus* and *Rosa* species. In total, 11.7% of all browsing events and 20.2% of all grooming events affected individual plants. The number of browsing events affecting these was significantly more frequent than in woods ($p < 0.01$) and woodland edges ($p = 0.01$) and significantly lower than the number for bush hedges ($p < 0.01$). For grooming purposes, the individual trees or bushes were visited significantly more frequently than

Table 5.5. Probabilities of error *p* for browsing frequency between woody vegetation formations of the Thuringian Rhoen ($\alpha \leq 0.013$[a] and 0.025[b], Bonferroni correction, *G*-test). [a] Significant, [b] marginally significant, *n.s.:* not significant

Formation	Individual	Bush hedge	Tree hedge	Wood edge
Individual	–	–	–	–
Bush hedge	0.003[a]	–	–	–
Tree hedge	<0.001[a]	<0.001[a]	–	–
Wood edge	0.010[a]	0.644 n.s.	<0.001[a]	–
Wood	<0.001[a]	<0.001[a]	<0.001[a]	<0.001[a]

Table 5.6. Probabilities of error *p* for browsing frequency between the woody vegetation formations of the Thuringian Rhoen ($\alpha \leq 0.013$[a] and 0.025[b], Bonferroni correction, *G*-test). [a] Significant, [b] marginally significant, *n.s.:* not significant

Formation	Individual	Bush hedge	Tree hedge	Wood edge
Individual	–	–	–	–
Bush hedge	0.002[a]	–	–	–
Tree hedge	<0.001[a]	<0.001[a]	–	–
Wood edge	0.010[a]	0.168	<0.001[a]	–
Wood	<0.001[a]	0.083	<0.001[a]	(events <5)

Table 5.7. Probabilities of error *p* for browsing frequency between the woody vegetation formations of the South Black Forest ($\alpha \leq 0.013$ and 0.025[a], Bonferroni correction, *G*-test). [a] Significant, [b] marginally significant, *n.s.:* not significant

Formation	Individual	Bush hedge	Tree hedge	Wood edge
Individual	–	–	–	–
Bush hedge	<0.001[a]	–	–	–
Tree hedge	<0.001[a]	<0.001[a]	–	–
Wood edge	<0.001[a]	0.026 n.s.	0.049 n.s	–
Wood	<0.001[a]	<0.001[a]	1.0 n.s.	0.049 n.s.

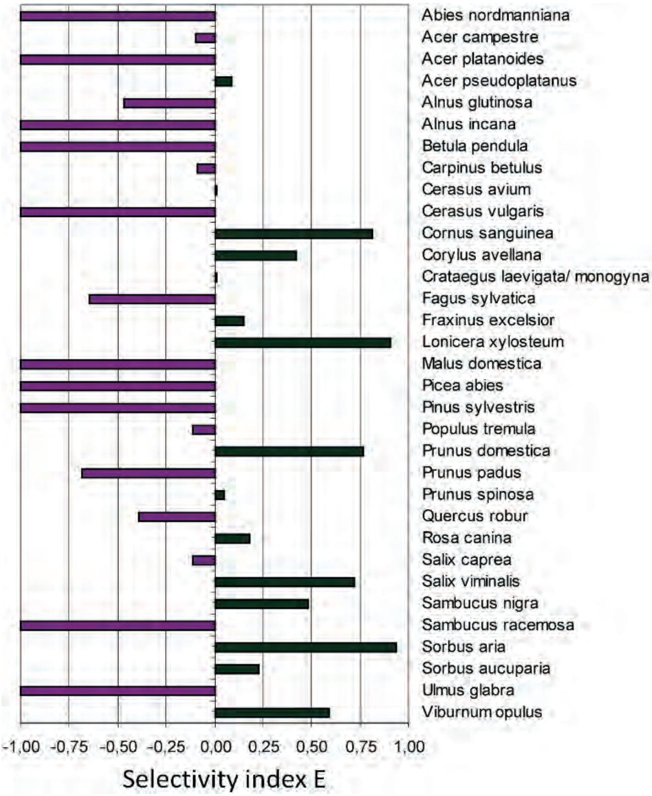
bush hedges, woodland edges and woods ($p < 0.01$; $p < 0.001$). Between the woodland edges and woods, no differentiation was possible because the number of grooming events was under five.

Also for cattle in the South Black Forest, a considerably lower significance for grooming behavior compared to browsing was found. A separate analysis of browsing and grooming (each behavior type 100%) showed clearly that there was a preference for individual trees with regard to both browsing and grooming. 52.4% of browsing events occurred on individual trees and were significantly the most frequent in comparison to other tree and bush formations ($p < 0.001$, Table 5.7). Grooming behavior on individual trees accounted for 70.6%. Bush hedges had 23.8% and woodland edges 12.6% of browsing events. Bush hedges received significantly more browsing than tree hedges and woodland trees ($p < 0.001$). All other comparisons revealed no significant differences. Tree hedges and woods both received 5.6% browsing events. Grooming on bush hedges amounted to 14.7% and on both tree hedges and woodland edges, 5.9%. The figure for grooming behavior was 2.9%. With respect to grooming behavior, the frequency of observations was too low to allow for a significant examination.

Woody Vegetation Species

With respect to the woody vegetation species in the pastures which were examined, the browsing preferences of the cattle were analyzed in both areas. Some of the species were frequently browsed and others hardly at all. For the analysis of species preferences, the mean browsing frequencies of recorded browsed species were compared for all investigated pastures within the whole observation period. The greatest frequency of browsing events for cattle in the Thuringian Rhoen was found for *Corylus avellana* and *Crataegus laevigata/monogyna*, followed by *Acer pseudoplatanus*, *Acer campestre*, *Prunus spinosa*, *Salix caprea*, *Fraxinus excelsior* and *Alnus glutinosa*. The calculation basis of the selectivity index E, the preferred species for browsing ($E > +0.25$) in the pastures of the Thuringian Rhoen include *Cornus sanguinea*, *Corylus avellana*, *Lonicera xylosteum*, *Prunus domestica*, *Salix viminalis*, *Sambucus nigra*, *Sorbus aria* and *Viburnum opulus* (Fig. 5.24). Species which were avoided ($E < -0.25$) include *Abies nordmanniana*, *Acer platanoides*, *Alnus glutinosa*, *Alnus incana*, *Betula pendula*, *Cerasus vulgaris*, *Fagus sylvatica*, *Malus domestica*, *Picea abies*, *Pinus sylvestris*, *Prunus padus*, *Quercus robur*, *Sambucus racemosa* and *Ulmus glabra*. The cattle exposed a neutral browsing behavior with respect to *Acer campestre*, *Acer pseudoplatanus*, *Carpinus betulus*, *Cerasus avium*, *Crataegus laevigata/monogyna*, *Fraxinus excelsior*, *Populus tremula*, *Prunus spinosa*, *Rosa canina*, *Salix caprea* and *Sorbus aucuparia*.

Fig. 5.24.
Selectivity index for browsing behavior in pastures of the Thuringian Rhoen, 2001. $E > +0.25$ = preferred, $E < -0.25$ = avoided, $E = +0.25 < 0 > -0.25$ = neutral. $n = 648$



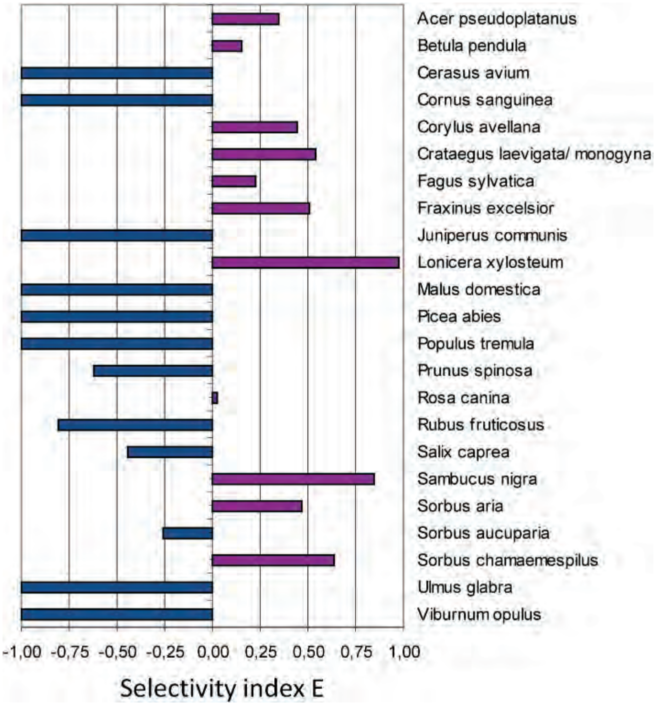


Fig. 5.25. Selectivity index for browsing behavior on pastures of the South Black Forest. $E > +0.25$ = preferred, $E < -0.25$ = avoided, $E = +0.25 < 0 > -0.25$ = neutral. $n = 143$

In the South Black Forest, the most frequently occurring browsing events were found for *Fagus sylvatica* and *Sorbus aria.* Similar to the Thuringian Rhoen, these were followed by *Corylus avellana* and *Crataegus laevigata/monogyna* as well as *Sorbus aucuparia* and *Prunus spinosa.* In addition, *Acer pseudoplatanus* and *Betula pendula* were more frequently browsed than other species. *Acer pseudoplatanus*, *Corylus avellana*, *Crataegus laevigata/monogyna*, *Fraxinus excelsior*, *Lonicera xylosteum*, *Sambucus nigra*, *Sorbus aria* and *Sorbus chamaemespilus* were preferred browsing choices (Fig. 5.25). The following species were avoided: *Cerasus avium*, *Cornus sanguinea*, *Juniperus communis*, *Malus domestica*, *Picea abies*, *Populus tremula*, *Prunus spinosa*, *Rubus fruticosus*, *Salix caprea*, *Ulmus glabra* und *Viburnum opulus.* The neutral species for browsing events include *Betula pendula*, *Fagus sylvatica*, *Rosa canina* and *Sorbus aucuparia.*

Effects on the Plant Structure for Individual Species

The tree and bush species which were affected by browsing events during the observation period were classified according to the extent of browsing. By means of the χ^2-test, it could be confirmed that there were significant differences ($p < 0.001$) in the extent of browsing between the different tree species. On the pastures of the Thuringian Rhoen, *Acer pseudoplatanus*, *Carpinus betulus*, *Corylus avellana*, *Fagus sylvatica*, *Fraxinus excelsior*, *Lonicera xylosteum*, *Prunus domestica*, *Salix caprea*, *Salix viminalis*, *Sorbus aria* and *Sorbus aucuparia* were exposed to a high level of browsing of over 50% (Fig. 5.26). Among the predominantly moderate to severe level of browsing are

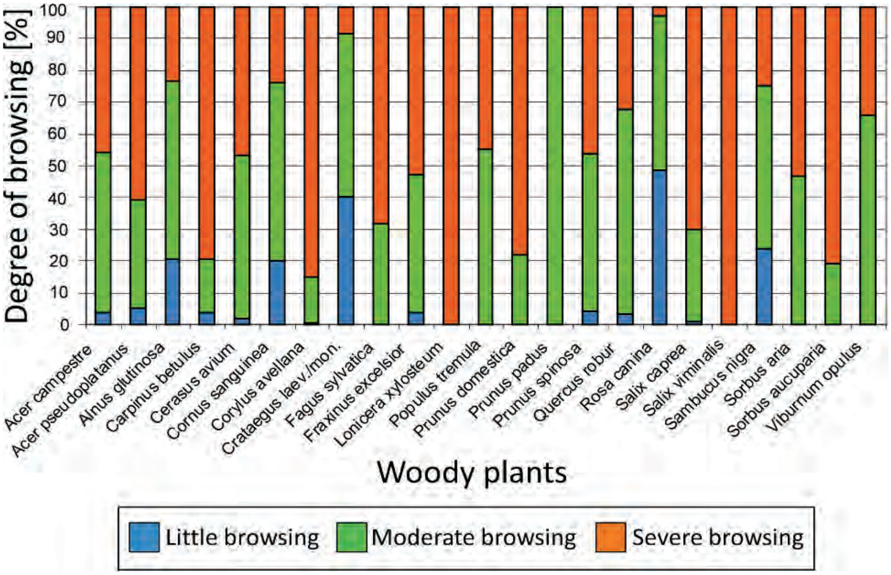


Fig. 5.26. Degree of browsing for woody species on the pastures of the Thuringian Rhoen where cattle browsing was observed. Total area = 1929 m²

Acer campestre, *Alnus glutinosa*, *Cerasus avium*, *Cornus sanguinea*, *Populus tremula*, *Prunus padus*, *Prunus spinosa*, *Quercus robur*, *Sambucus nigra* and *Viburnum opulus*. A low to moderate level of browsing was found for the thorny species *Crataegus laevigata/monogyna* and *Rosa canina*.

On the pastures of the South Black Forest, *Acer pseudoplatanus*, *Fraxinus excelsior*, *Lonicera xylosteum*, *Sorbus aria* and *Sorbus aucuparia* were among the species classified with a severe browsing level of more than 50% (Fig. 5.27). A predominantly moderate to severe browsing level was found in *Corylus avellana*, *Salix caprea* and *Sambucus nigra*, but also the thorny *Crataegus laevigata/monogyna* and *Rosa canina* are in this group. Species with mainly low levels of browsing are *Betula pendula*, *Fagus sylvatica* and the thorny *Prunus spinosa* and *Rubus spec.*

5.3.4
Comparative Assessment of the Findings

Species Preferences

On all of the investigated areas of the Thuringian Rhoen and the South Black Forest, woody vegetation structures were present which were accessible to the cattle. These structures served mainly as protection against unfavorable weather conditions and also as a source of nutrition (browsing), for bodily care (grooming), for occupation ('boredom') and as a resting place. The browsing events were a much larger component than grooming behavior. With respect to the tree and bush formations, the significantly most frequent contacts and visits of the cattle of the Thuringian Rhoen involved tree

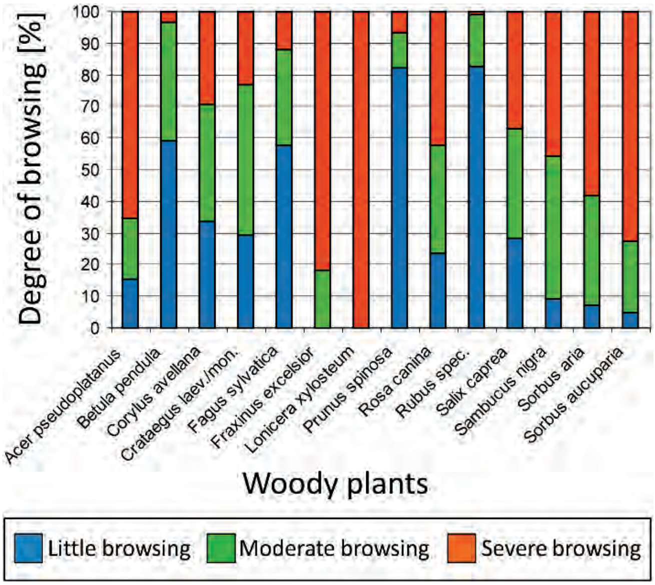


Fig. 5.27.
Degree of browsing for woody species on the pastures of the South Black Forest, 2001, where cattle browsing was observed. Total number = 6316

hedges, which stood out in comparison to other formations. Tree hedges are accessible from two sides and enable a comfortable browsing and grooming opportunity. In addition, tree hedges offer protection on both sides and allow a large number of cattle equal shelter. Behavior patterns by which high-ranking animals achieve preferred places can be largely excluded in and near to tree hedges. Low-ranking animals have the possibility of avoiding high-ranking ones. Sambraus (1978) and Buchholtz (1988) report that in the main, cattle seek out tree hedges, particularly in conditions of wind, heavy rain and long periods of heat with strong sunshine. In particular, the set stocking pastures *EB* and *LA* were crossed with long tree hedges, the former characterized mainly with willows (*Salix viminalis*) and the latter with alder (*Alnus glutinosa*) and other tree species. Following long years of grazing, the tree hedges showed typical browsing patterns in the low area of the crown.

Tree and bush browsing was differentiated by Rahmann (1998) according to cropping of the leaves, saplings and stripping of the bark. In our study, the browsing of leaves and young saplings were observed as one aspect. The stripping of bark was not observed for any of the cattle flocks. The tree hedges on the pastures *EBU*, *RH* and *RHU* consisted of mixed species formations. On the pasture *HB*, there were mainly thorny bush hedges, particularly Hawthorn (*Crataegus laevigata/monogyna*) and Dog Rose (*Rosa canina*), which showed clear signs of browsing. The pastures of the South Black Forest were scattered with individual trees and bushes. Although these were mainly thorny species such as Hawthorn and Dog Rose, as well as Whitebeam (*Sorbus aria*), in comparison to other formations they were significantly the most frequently browsed. Overall, the bush hedges were significantly more browsed compared to the woodland edges and woods. According to the selectivity index (Schwarz and Schultka 1988), the most browsed and therefore probably the tastier species in both investigation areas were mainly *Corylus avellana* and *Acer pseudoplatanus*. But even thorny species such as *Crataegus laevigata/monogyna* and *Rosa canina* were preferred or at least treated neutrally. *Prunus spinosa* covered large areas and produced high-growing and in part impenetrable hedges, and despite frequent recordings of browsing events, was avoided in comparison to other species. While *Fagus sylvatica* in the Thuringian Rhoen was largely avoided, this species was on the preferred list in the South Black Forest. The browsing of conifers such as *Picea abies* and *Pinus sylvestris* were never observed, despite their frequent occurrence. According to research on browsing behavior done by Buttenschon and Buttenschon (1978) in Denmark, cattle preferred *Salix* spec., *Betula pendula*, *Sorbus aucuparia* and *Populus tremula*. *Quercus robur*, *Malus domestica* and *Prunus spinosa* were moderately browsed. *Juniperus communis* and *Rosa canina* were not browsed. Browsing investigations by von Bokdam et al. (2003) in the Netherlands documented preferences for *Sorbus aucuparia*, *Quercus robur*, *Frangula alnus* and *Prunus serotina*. *Pinus sylvestris*, *Betula pendula* and *Rubus fruticosus* were avoided. For woodland grazing in Galicia, the cattle disdained species of *Rubus*, *Quercus* and *Castanea sativa*, but *Pinus* was frequently browsed (Silva-Pando et al. 2002). Gerken and Sonnenburg (2002) report that semi-wild Heck cattle in the Hutewald project area browsed on *Fagus sylvatica*, *Rubus idaeus* and *R. fruticosus*. Semi-wild cattle in the Höltigbaum project area preferred to browse on Rosaceae and *Rubus idaeus*. They severely browsed *Salix* spec. and *Alnus glutinosa* and moderately browsed *Crataegus laevigata/monogyna* and *Quercus robur* (Härdtle et al. 2002). Overall, the young and middle-aged trees there were considerably damaged by grazing animals, whereas adult and older trees were not adversely affected.

The tree species with low preference for the cattle and which were classified as slightly browsed also appear to be avoided by wild animals. These include mainly thorny species such as *Prunus spinosa* and *Rubus fruticosus*. In the South Black Forest, both species form thick hedge structures. The spreading of these structures will probably continue, as according to the observations of Stuth (1991), cattle prefer to walk along open, firm paths rather than attempt to penetrate thick bushes or difficult terrains. According to Fraser and Broom (1990), hairy and thorny plants are avoided. Buttenschon and Buttenschon (1978) report that the way cattle take up their nutrition makes cattle incapable of heavy browsing on thorny species. However, these species are not completely avoided, as the browsing of *Crataegus laevigata/monogyna* and *Rosa canina* has shown.

Visited Species

The visiting preferences for trees and bushes were examined using calculated preference indexes (Ivlev 1961; Jacobs 1974) in the second and third years of the investigation with a comparison of the individual pastures of the Thuringian Rhoen. The preference indexes gave a continuous gradient according to pasture size. On the smallest pasture (*RHU*), trees were more strongly preferred as visiting places than on the two large set stocking pastures, which in turn were preferred to the two very large set stocking pastures (*EB* and *LA*). This correlation results from the widely distributed areas of woody vegetation on the large pastures. The absolute proportion of trees on the pastures *EB* and *LA* were lower than on both of the rotational pastures and were more widely distributed because of the size of the land. On the smaller rotational pastures, the occurrences of trees and bushes were more concentrated relative to the area and the routes to trees from feeding places in the open areas were short. The set stocking pasture *RH* had the largest proportion of trees and bushes. The preference levels were in the area of neutral to positive.

Overall, it can be concluded from the preference results that cattle generally use woody vegetation formations when these are available to a sufficient extent. Trees and shrubs are not seen as necessary for survival by grazing animals on the pastures of Central Europe, as is described by Saville (1981) with respect to semi-arid and arid areas, where they contribute substantially to the survival of grazing animals. However, they form the preconditions for a good quality of life and therefore the well-being of the animals, which is reflected in their health and weight gain. In addition, trees provide important shelter against weather for the cattle. Pastures with large proportions of trees and shrubs, particularly with thick growths and areas of evergreens, are suitable for cattle to remain outdoors over the whole year. The practical experience of many cattle farmers and the results from studies (for example, Ebert 1996; Zube 1996) prove that cattle prefer to seek out natural tree structures and will hardly accept artificial structures. Belsky et al. (1989) investigated the ground conditions around trees and bushes on pasture. The results showed that these cause a lowering of sun radiation, soil temperature and rainfall. Cattle enable the distribution of nutrients over the roots of the trees.

Woody Vegetation Structures

The structures of trees and bushes are affected through the browsing and grooming behavior of cattle. Fraser and Broom (1990) consider the presence of trees and bushes to be very important for the well-being of cattle as they enable the carrying out of grooming behavior. This behavior is expressed through rubbing the head or body against the tree. This can cause the breaking off of branches, damage to the bark the complete breaking of young saplings (Fraser and Broom 1990). However, adverse effects caused by grooming were found to be slight during the investigation. Buttenschon and Buttenschon (1978) also came to these results. Hornless breeds such as Holstein Frisians have an even smaller effect on shrubs and young trees compared to horned breeds, according to WallisDeVries (1994). Investigations by Bokdam and Gleichman (2000) showed that cattle grazing in heathlands did not prevent the encroachment of pine and birch. For the removal of young conifers and *Prunus serotina* in Denmark, 'forest cattle' were bred (Voigt 2002). So far, there has been a reduction in the numbers of *Betula* spec., *Salix* spec., *Populus tremula* and *Rubus fruticosus* through this breed. However, long-term grazing by cattle alone cannot keep an area permanently open, according to Voigt (2002). The results from Buttenschon and Buttenschon (1978) and Bokdam et al. (2003), however, strengthen the notion that cattle are capable of driving certain ecological mosaic cycles through their effects on trees and bushes. They can suppress woodland undergrowth and create grazing swards until more resistant shrubs or trees move in (Bokdam et al. 2003). Theoretical concepts such as that of Vera (2000) propose a park-like character with mosaic grasslands, individual trees and groups of trees or bushes for the Central European natural landscapes, in which herbivores such as cattle play an important role in the regeneration of these structures and the vegetation succession. The thinning out of woodlands through animal browsing is, in the view of Hüppe (1997), mainly a result of the damage to and the destruction of young growths. Through the failure of secondary tree growth, gaps appear in the tree cover which allows the migration of light-loving grasses, shrubs and bushes. With more intensive grazing, the woodland breaks up into a park-like structure and open, grassed pathways arise which alternate with groups of bushes or trees in a mosaic pattern. If grazing decreases, then as well as individual stages of degradation, there is also a return to woodland formation processes through encroachment. Studies by Bokdam (2001) have also shown that cattle browsing and grazing drive the cyclical succession. The trampling effects of cattle in itself destroy vegetation and create gaps for a new wave of growth for the same and other plants.

Grazing with grass-eating herbivores such as cattle and horses is, according to Vera (2000), necessary for the establishment of *Quercus* spec., *Corylus avellana*, wild fruit trees (*Pyrus pyraster*, *Malus domestica*, *Prunus domestica*) and thorny trees such as *Crataegus* spec. and *Prunus spinosa*. *Quercus* spec. and *Corylus avellana* require a high amount of light for regeneration and cannot get established in closed woodlands (Vera 1998). They regenerate in areas in which cattle and horses control succession, such as in pasturage forests or grazed woodlands, and in extensively used pasturelands. Oak is able to germinate under a closed canopy but die off in the following years if there is no sunlight access (Wolf 1988; Ziegenhagen and Kausch 1994). On the other hand, there is often a quite adequate amount of light for the development of oak saplings in hedges. Other typical species which are associated with park-like landscapes or light woodland structures include *Malus domestica*, *Pyrus pyraster* and *Sorbus aucuparia* (Vera 1998). For new colonizations, the resistance of the individual species against browsing and their ability to regenerate after damage is important (Hüppe 1997). This applies particularly to tree saplings. The process of selection through grazing has a positive effect on all species which are protected against browsing with thorns or spikes, such as *Prunus spinosa*, *Crataegus* spec. and *Rosa canina*, according to Hüppe (1997). The thorns are a passive defense mechanism for plants against over-grazing (Rahmann 1998). Along with the size of leaves and secondary substances, spikes and thorns are part of the morphological and physiological properties which affect the selection decisions of cattle (Stuth 1991). These thorny shrubs have, however, a constructive significance in the dynamics of vegetation cycles. Because of their ability to regenerate quickly through the growth of polycorms, they can become dominant on permanently grazed areas with nutrient-rich soils. Through grazing, growth forms with apical dominance arise in which the highest part of a cropped shoot over the ground branches out. In this way, thorny vegetation in connection with cattle browsing is causally responsible for the dynamic processes of degradation and regeneration (Pott and Hüppe 1994). This also explains the alternating aspects of displacement, new growth and destruction of groups of trees and bushes through grazing over different time intervals. It could also be the case that because of the preference of cattle for grazing along the edges of tree structures, the spatial distribution of these over the area could also be influenced over longer periods.

A large part of the biomass from trees and shrubs cannot, however, be utilized by cattle because it is outside of their reach and therefore protected from them (Vulink

2001). On the pastures in the Thuringian Rhoen and the South Black Forest, large closed areas of vegetation were fenced off. Because connected areas of woodland are covered by federal and state forestry legislation, they are often excluded from pasturing. Since the end of the woodland grazing laws of the nineteenth century and the associated separation of woodland and pasturage management, cattle and other grazing animals, which through their origins are tied to woodland as well as open land biotopes and have correspondingly based their feeding strategies on these, are not tolerated in the environment typical of their natural requirements. However, it is the very clearings which are initiated through browsing, grooming behavior and the breaking of smaller plants which are the preconditions for the regeneration of trees and the creation of new habitats with new niche qualities. In addition, on warm summer days or during heavy rain, they provide protective shelters which are important for the well-being of the cattle. Within a few years, in both the Thuringian Rhoen and the South Black Forest, predominantly hawthorn bushes had developed to so-called 'cow bushes' (Kratochwil and Schwabe 1987) or 'bowers' (Plachter et al. 2004) with similar structures. Typically, the inside areas consist of bushes and low-growing trees such as *Crataegus* spec., *Rosa canina*, *Sambucus nigra*, *Corylus avellana* and *Salix* spec. or early stages of pasture beech (*Fagus sylvatica*) and are easily accessible through the activities of cattle.

The structures of the woody vegetation in the investigation areas exactly reflected the pattern of browsing as well as the dimensions for withers height and the length of the outstretched neck of the cattle. The yurt-shaped bush hedges were frequently broken through with a ring of blackthorn (*Prunus spinosa*) and with several access ways. A further characteristic consisted of large and accessible hawthorn woods, particularly on the pasture *HB*, which resembled the Mediterranean macchie.

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5.4
Browsing of Woody Vegetation by Cattle on Large-Scale Pastures of the Stora Alvaret on the Island of Oeland, Sweden

Christiane Feucht

5.4.1
Introduction

Among the few places in Central Europe in which large-scale pasturing with livestock has remained in existence is the Great Alvar (*Stora Alvaret*) on the island of Oeland in southern Sweden (cf. Chap. 3). The Alvar has been subject to major changes through the interaction of its relatively hard natural conditions and cultural influences during its history (van de Maarel and Sykes 1997). Overgrazing and tree felling in earlier times led to the suppression of the tree vegetation, while in recent times, a reduction in grazing has resulted in an increase in encroachment (Rosén 1988; Rosén and Borgegård 1999). However, the influence of livestock (cattle and sheep) on the trees and bushes is still today very considerable. In addition, it is appreciable that on the long and extended pastures, the livestock can display their natural repertoire of behavior virtually without hindrance. Because of this situation, the area is particularly suitable for a close-up study of the influences of cattle on tree and bush vegetation.

In a study from May to September 2002, two set stocking pastures of 640 ha (cattle pasture: 40 young bulls, 18 heifers; stocking density: 0.05 LSU ha^{-1}) and 599 ha (Texel and Gotland sheep; 205 adults, 130 lambs; stocking density: also 0.05 LSU ha^{-1}) were investi-

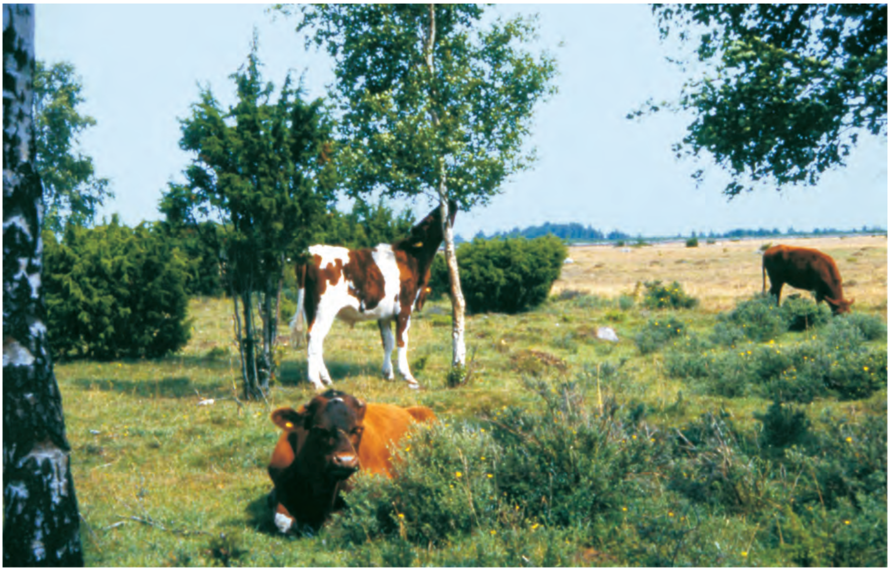

Fig. 5.28. Tree browsing by cattle on *Betula pendula* on the Alvar, 2002 (photo: C. Feucht)

gated comparatively with respect to the effects of livestock on the vegetation (particularly woody species) and the habitat structure. While the sheep-grazing area had been continuously grazed over the previous decades, the cattle pasture had lain fallow for fifteen years and only came back into use as a pasture in 1995. The focus was on the analysis of the influences of cattle on woody vegetation. In this way, the question to be answered was whether through grazing with cattle in the given conditions, the growth of woody species would be suppressed and encroachment could be prevented (Fig. 5.28).

5.4.2
Methodology

Woody Species and Their Occurrences

On both areas and along parallel tracks (cattle: 8, sheep: 7), each measuring about 1 500 m length and 2 m width, the number of woody species and their density per 100 m² was recorded (position determined with GPS; in total, 22 700 m transect lengths) (Fig. 5.29a).

Transects around Individual Species

From each of 25 individual woody plant species, two radial transects of 7 m length were laid out on which the following parameters were recorded from sampling squares measuring 25 × 25 cm (2 × 28 squares per shrub): maximum and minimum height of vegetation; degree of cover (according to Braun-Blanquet; estimated in steps of 5%) of herbaceous plants, grasses, dead material, moss, lichen, open ground; grazing intensity (estimated percentage of grazed vegetation); number of species, flowers (quantatively assessed). In order to eliminate any microclimatic effects on the vegetation around the shrubs, the transects were laid out in random directions (Fig. 5.29b). In addition, the type of location (dry, fresh, wet) was determined through an appraisal of the dominant herbaceous species.

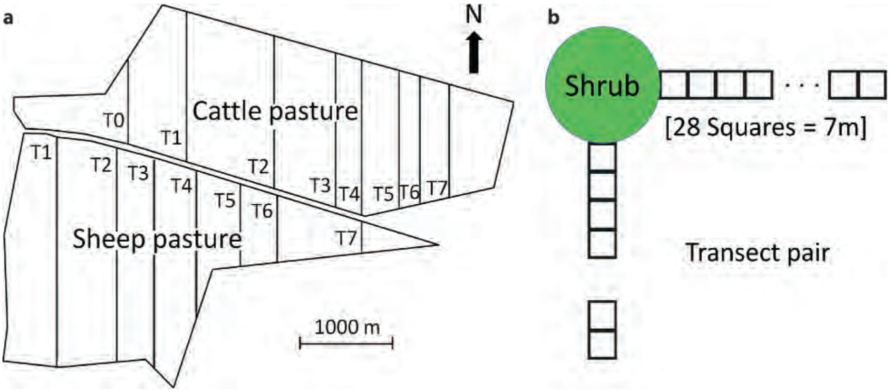

Fig. 5.29. **a** Transects on both pastures; **b** configuration of the transects from sampling squares around shrubs

Browsing Behavior

The browsing behavior of cattle on woody vegetation was recorded on seven days for in each case, four hours, through direct observation ($n = 130$ browsing observations). The parameters for recording were: type of species, size of species (cm), duration of browsing activity (min; s), cropping height (cm; minimum and maximum height determined and classified) (Table 5.8), number of browsing places (quantitatively assessed and classified) (Table 5.9), combination with grooming behavior (qualitative: observed or not).

Table 5.8. Classifications for cropping height – cattle

Class	Interval (m)	Description
1	0.00–0.40	Head bowed for cropping
2	0.41–0.90	Head straight, normal posture
3	0.91–1.40	Head raised
4	1.41–1.90	Neck stretched

Table 5.9. Classifications for number of browsing places

Class	Number
1	1 – 4
2	5 – 9
3	10 – 14
4	15 – 20
5	>20

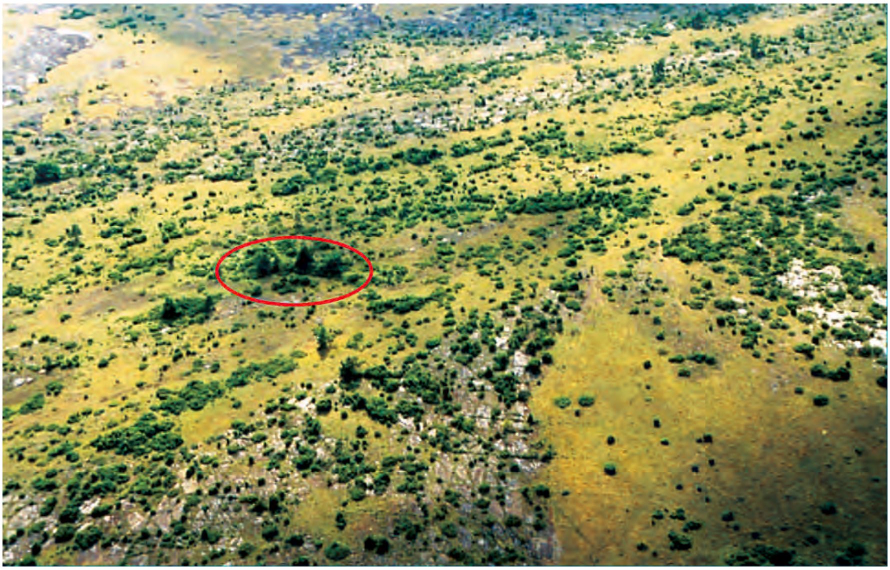

Fig. 5.30. Tree groups on the Alvar, 2002 (photo: C. Feucht)

Table 5.10. Classifications of the parameters

Class	Description
0	No effects present
1	Small effects present
2	Moderate effects evident
3	Strongly affected
4	Very strongly affected

Table 5.11. Density

Class	Designation	Description
0	Open	Trees/groups very loosely spread, easy access
1	Access possible	Trees/groups in low bushes, open on at least one side
2	Access difficult	Trees/groups with low bushes
3	Thick	Trees/groups in thick bushes
4	Very thick	Trees/groups in very thick, high bushes
5	No access evident	Trees/groups with no access

Effects on Groups of Trees

Islands of trees, or tree groups, are defined here as adjacent woody vegetation which through their spatial characteristics stand out from the area and which as a rule have an island characteristic on the Alvar (Fig. 5.30). On the cattle grazing area, all (26) tree groups were positioned using GPS. In their immediate vicinity, the following parameters were estimated in five classes (Table 5.10): trampling, breakage signs, browsing, dung. The mode value of these parameters is the sign classification. In addition, the number and size of woody saplings were measured and the vegetation density was determined (Table 5.11).

Effects on Solitary Trees

For 280 solitary trees on the cattle pasture, the following parameters were investigated, again in five classes: species type, size, existence of a leader (qualitative), browsing class and breakage class (Table 5.10).

5.4.3
Results

Species Types and Occurrences

Nine species of woody vegetation were found on the sheep pasture and twenty-nine on the cattle pasture. The latter included several ruderal species which occur close to settlements and had grown wild (for example, *Malus sylvestris*). The number of species,

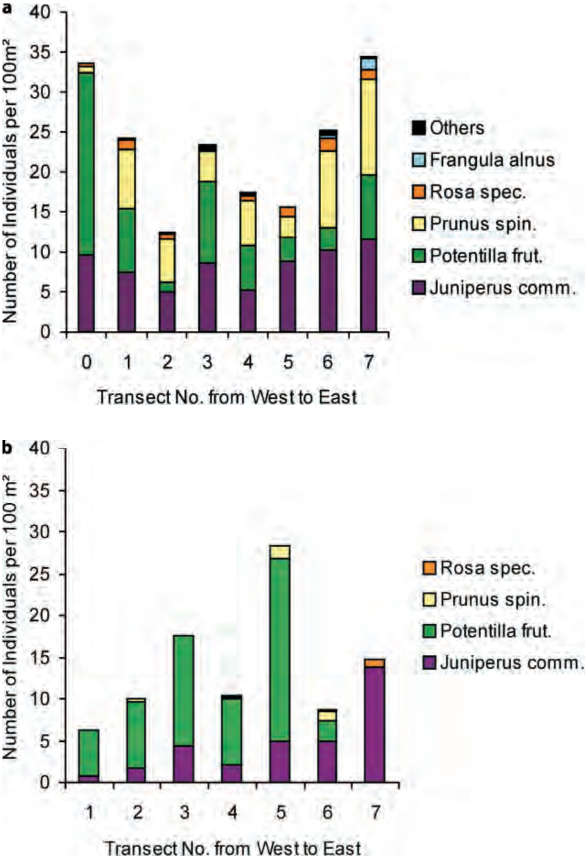

Fig. 5.31. Occurrence of shrubs on the 8 and 7 transects over **a** the cattle pasture and **b** the sheep pasture on the Alvar. The category 'others' includes the species *Cotoneaster integerrimus*, *Pinus sylvestris*, *Crataegus monogyna* (average value of 0.3 individuals for each 100 m transect)

and with this, their density (over a comparable area) is higher on the cattle pasture. There, the dominant species are *Juniperus communis*, *Potentilla fruticosa* and *Prunus spinosa* (Fig. 5.31).

Browsing Behavior

The minimum timed period for a single browsing observation on the cattle pasture was 0:04 min and the maximum was 10:24 min. The most frequently browsed species was *Frangula alnus* (63 observations, $n = 130$, Bonferroni test, $p < 0.05$). *Frangula alnus* and *Pinus sylvestris* were more frequently browsed than other species (t-test, $p < 0.001$). The species with the most places browsed was *Pinus sylvestris*, followed by *Frangula alnus* and *Salix caprea* (Table 5.12). The range of heights for browsing lay between 8 and 200 cm. Browsing at the normal head position between 41 and 90 cm was the most frequent (t-test, $p < 0.001$) and resulted in most of the browsed places on the plant (Table 5.13). At this class of browsing height, 88% of the individual species no longer had a leader. 23% of all browsing observations were in combination with the cattle rubbing against the vegetation.

Table 5.12. Mode value of browsing classifications for most frequent species

Species	*n*	Mode of browsing place class
Frangula alnus	63	2
Pinus sylvestris	18	3
Betula pendula	10	1
Salix caprea	9	2

Table 5.13. Results of the classification for browsing height

Class	Class interval (m)	Number observations	Mean browse height	Standard deviation browse height	Mean size	Standard deviation size	Mode browse place class
1	0.00–0.40	22	0.33	0.07	0.86	1.18	1
2	0.41–0.90	75	0.60	0.15	1.12	0.74	2
3	0.91–1.40	28	1.09	0.14	2.26	1.33	1
4	1.41–1.90	8	1.62	0.15	3.93	1.60	1

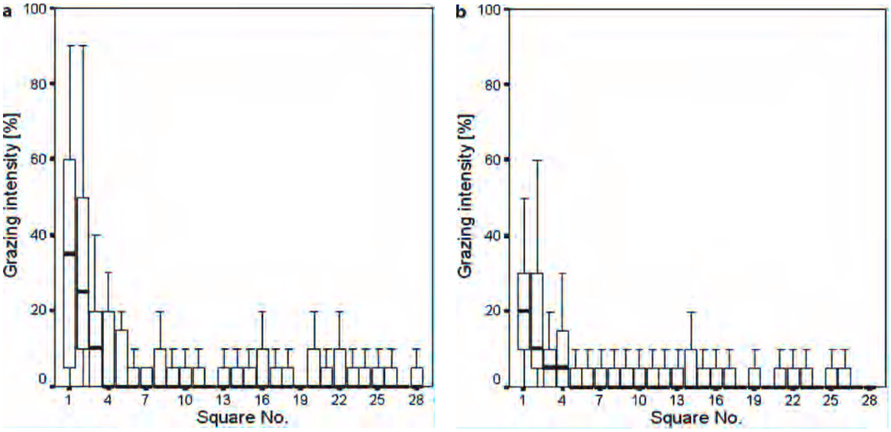

Fig. 5.32. Box-Whiskers plots for grazing intensity around woody species in the transects **a** on the cattle pasture, **b** on the sheep pasture. The box is in the interquartile area with 50% of the values. The lines leaving the box lead in each case to the highest and lowest value, without considering outliers. The line crossing the box gives the position of the median

Transects around Individual Shrubs

The average grazing intensity for the herbaceous-grassy vegetation round the woody species is low. It is concentrated on the first meter (the first four sampling squares) and decreases rapidly with increasing distance from the woody species. In 19 (cattle) and 21 (sheep) from 25 transect pairs, the grazing intensity is greater in the first meter (*U*-test, $p < 0.001$). On the sheep pasture, this finding is however quantitatively less evident (Fig. 5.32a,b).

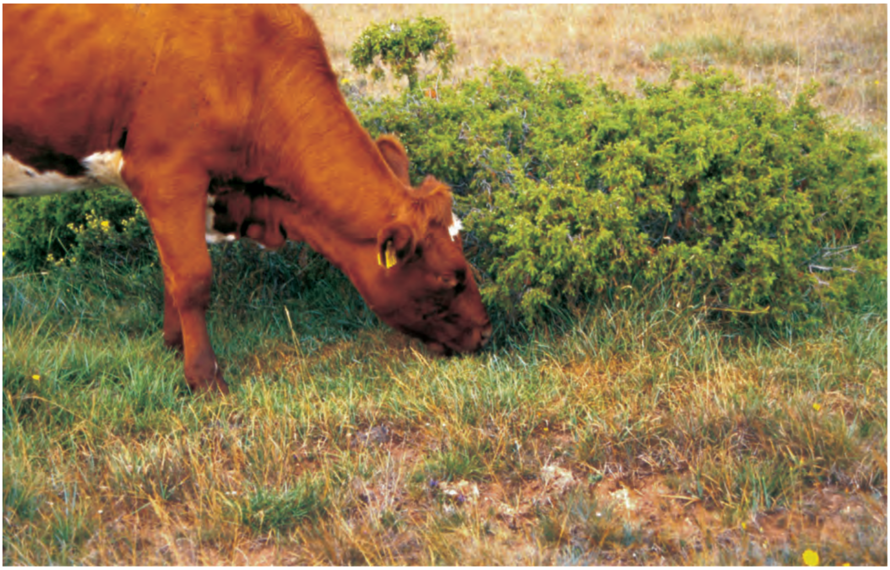

Fig. 5.33. Cow grazing around juniper bush. Alvar, Oeland 2002 (photo C. Feucht)

In particular, 'fresh' locations were more strongly grazed by the cattle (Fig. 5.33) than by the sheep ($p < 0.001$). The sheep preferred to graze on wet locations ($p < 0.01$). The sheep pasture is more species-rich on wet locations than the cattle, whereas the cattle pasture has more species on dry areas (Spearman-Rang correlation coefficient, highly significant or significant). The estimated proportion of dead mass is for all location types, greater for the sheep than for the cattle (H-test, SRk $r = 0.247$; $p < 0.01$). With regard to the number of flowers and the number of species (median = 7 per sampling square), no statistical difference exists. In addition, there was no significant difference with regard to the proportion of open ground around woody species when both areas were compared.

Effects on Groups of Trees

In most of the groups of trees, signs of browsing could not be shown (mode = 0). 18 of the 26 tree groups on the area could be classified as not affected or only slightly affected (mode values for sign classes 0 and 1, Fig. 5.34).

There was, however, hardly any sapling growth found in the tree groups. Apart from numerous shoots sprouting from the roots of *Populus tremula*, a total of only 3 saplings < 1 m were recorded. These also were affected by browsing damage.

Solitary Trees

The most frequently occurring species of solitary tree on the cattle pasture is *Pinus sylvestris* (168 of 280 mapped trees). The damage to single trees through browsing is overall slight (mode = 1), but signs of browsing could be established on 97% of all surveyed trees. Breakage damage through rubbing was found to a moderate extent

Fig. 5.34.
Number of tree groups in the area with classes of impact

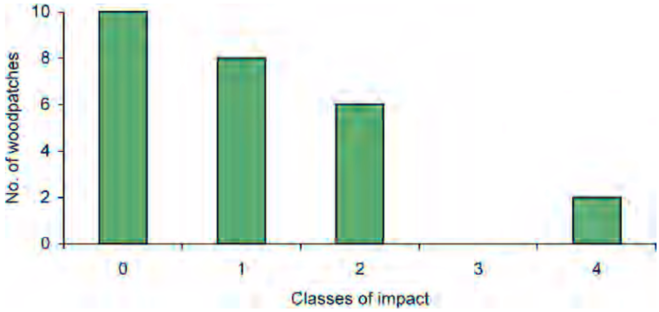

Table 5.14. Results of the investigation for solitary trees; species are ordered according to frequency of occurrence

Species	Number	Mode browse class	Mode breakage class	Mode leader[a]	Mode growth form[b]
Pinus sylvestris	168	1	2	1	1
Salix caprea	50	4	4	0	2
Betula pendula	34	2	4	0	2
Sorbus intermedia	16	1	2	1	1
Fraxinus excelsior	5	4	1	0	1

Parameters containing nominal data: [a] Leader {0 = leader not present, 1 = leader present}; [b] growth form {1 = tree, 2 = bush}.

(mode = 2). Damage caused by browsing and breakage are positively correlated (SRk, $r = 0.517$; $p < 0.01$).

The most severe browsing and breakage damage was found on deciduous trees (Table 5.14).

85% of *Betula pendula* trees under 2 m high did not have a leader ($n = 20$). The leader was damaged mainly through breakage. Through this, a multi-stemmed morphology can arise (e.g., Burrichter 1984; Lohmeyer and Bohn 1974) (Fig. 5.35).

5.4.4
Discussion

The amount and spatial distribution of woody species in the investigation area is not only a result of the influences of grazing animals, but is also affected by the various forms of use over time which have occurred there (left fallow, encroachment clearance, etc.). However, Rosén (1988) assumes that the varied situation for woody species with regard to occurrence and number of species is strongly affected by grazing animals. This cannot be confirmed by the investigation presented here. The influence of cattle on the woody vegetation with this level of stocking density is only slight. The larger range of species and the higher density on the cattle pasture are noticeable differences in a comparison with the species present on the sheep pasture. Various investigations

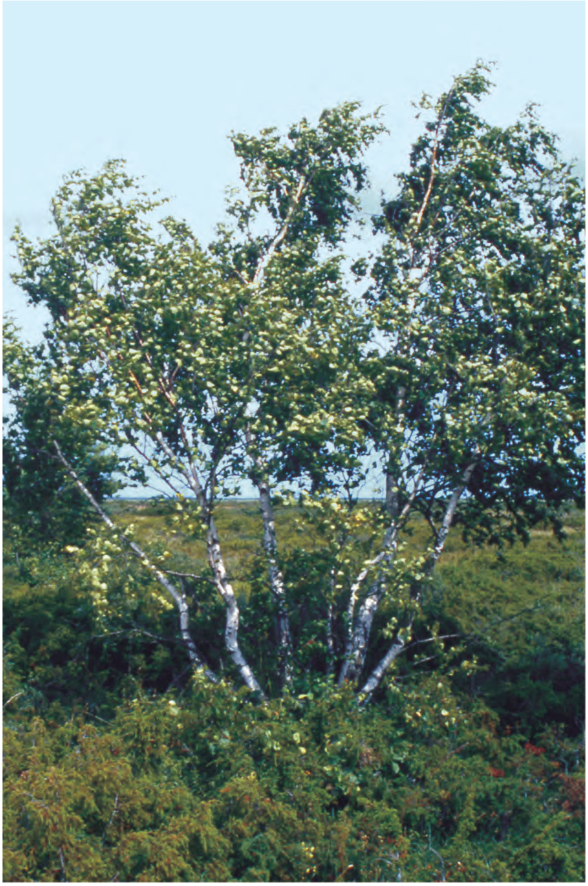

Fig. 5.35.
Multi-stemmed *Betula pendula* on the cattle pasture, Alvar, Oeland, 2002 (photo: C. Feucht)

on the browsing behavior of cattle and sheep on woody vegetation have shown that sheep browse these more severely than cattle (e.g., Buttenschon and Buttenschon 1978; Haeggström 1990). This could not be established on the Alvar and the impression arose that it was not the influence of livestock on woody vegetation but to a much greater extent, the conditions for growth and the history of land use which are the decisive factors in the state of this vegetation.

Grazing animals cause local effects on woody vegetation in their habitat through browsing and grooming behavior. Deciduous trees showed severe browsing and breakage damage. But also *Pinus sylvestris*, the most frequently occurring tree species on the cattle pasture, was very frequently browsed but mainly damaged through breakage.

There is a clear difference here between the behavior of cattle and sheep. Cattle have a great need to rub themselves against trees. Because of their size and weight, they can cause considerable damage to the trees. Both the browsing and the breakage effects lead to an inhibition of the growth of the tree. Through regeneration and compensatory growth, many structures and growth forms are created (e.g., Burrichter 1984; Lohmeyer and Bohn 1974).

The heterogeneous use of the area through cattle and their grazing and browsing behavior cannot prevent the initial growth of bushes, trees or the formation of tree groups. A dynamic development of woody vegetation influenced by the grazing animals, as has been described in detail for forest grazing landscapes, could not be demonstrated on the Alvar.

The groups of trees were only marginally damaged by the cattle. However, it could be established that in these groups, there were hardly any saplings growing, or that these were severely damaged, so that a thickening or spreading out of the species at the start of succession is inhibited.

Groups of trees are used by the cattle as places to sleep overnight, and also serve to protect them from sun, wind and rain. They also probably assist the cattle in orientation around the area.

The differences in the type of grazing between cattle and sheep also lead to differences in the composition of the plant communities. Sheep are more selective than cattle in the search for nutrition (Buttenschon and Buttenschon 1982; Nicholson 1970; Pott and Hüppe 1994). Because of the anatomically narrower mouths, sheep are capable of grasping specific plant species or parts of plants, growing very close to the ground (Briemle 1987; Edwards et al. 1994; Lynch 1992; Pott and Hüppe 1994). Because of this selective characteristic, a part of the vegetation is not utilized. Following from this, a higher proportion of dead mass could be shown in the plant communities on the sheep pasture.

According to observations by Rosén (1982), sheep grazing caused the disappearance of species such as *Helianthemum oelandicum* and *Anthericum ramosum*. However, this study was unable to demonstrate any differences in the number of flowers in transects around shrubs or in the number of species between the cattle and sheep pastures.

Cattle graze more heavily around shrubs than sheep. The grazing behavior of cattle around bushes can, according to observations by Brouwer (1962) and Rosén (1982), be explained through the preference for grazing in areas protected from the wind, and also because plants growing on sites which are protected against sun and wind by bushes have a higher water content and therefore offer preferred grazing. This can contribute locally to the spreading and distribution of bushes because with the herbaceous vegetation are also seedlings of woody vegetation and root runners nearby which are largely or completely eaten.

Despite the demonstrated influences of cattle on the woody vegetation, grazing at the present level is insufficient to prevent encroachment. Additional management measures in the form of bush removal, corresponding to the earlier level of pasture management, are unavoidable in places if the open character of the Alvar is to be maintained.

Acknowledgments

The Ekologiska Forskningsstation Oeland served as the base station for this work. I'm grateful to all the members, particularly Eje Rosén for advice on the contents and Jan Tengö and Lennart Agren for the logistical support. Thanks also to Helena Lager and Susanne Forslund from the Kalmar District Administration for providing me with information.

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Chapter 6

Mesoscale Effects

6.1
Mesoscale Behavioral-Ecological Effects of Cattle on Large-Scale Pastures of the Thuringian Rhoen and the South Black Forest

Almut Popp

6.1.1
Introduction

The effects of livestock on the structure and species numbers of pastureland are to a large extent determined by their individual and social behavior. Although there are already a fairly large number of studies available, only a few combine the ethological findings with the mesoscale habitat structure of the whole area and hardly any with the available area size. It can be assumed, however, that husbandry forms, area size and the structuring of the pasture would have a significant influence on the behavior of the animals and a larger area and a more varied structure would lead to a diversification of the type of behavior, so far as particular patterns from behavioral elements in the repertoire of livestock are actually still available. This applies also to findings on the keeping of semi-wild, so-called primitive livestock breeds.

The investigation presented here uses behavior-ecological and landscape-structural methods to compare the effects of modern cattle breeds on the currently normal, small-plot rotational pastures with those on relatively large-scale set stocking pastures with different stocking densities in an actual farm enterprise and on traditional common grazing land.

6.1.2
Methodology

Areas

The outdoor investigations on domestic cattle in the years 2001 to 2003 were carried out on differently-sized pastures with different stocking densities for suckler cow farming and heifer breeding. For the purpose of the investigation, existing pastures belonging to the agricultural enterprise 'Agrarhöfe GmbH Kaltensundheim' (Thuringian Rhoen, administrative district of Schmalkalden-Meiningen) were used. The grazing system in the Thuringian Rhoen was based on four set stocking pastures (*Hemschenberg*, *Lichtenau*, *Rotenhauck*, *Ellenbogen*) from 20–50 ha with stocking densities from 0.5 to 2 LSU ha^{-1} (Table 3.1). Of these, two were set stocking pastures occupied by suckler cows and calves of the Fleckvieh breed and two with Black Pied heifers. Parallel to the set stocking pastures, two rotational pastures of 5 and 6 ha with stocking densities of 6 and 7 LSU ha^{-1} respectively were investigated, both used for heifer raising. Both of the rotational pastures (*Rotenhauck-R*, *Ellenbogen-R*) bordered on the set stocking pastures of the same names. In the years of investigation, the grazing area of the *Lichtenau* was enlarged from 37 to 50 ha and the *Rotenhauck-R* from 5 to 6 ha.

Accompanying investigations were carried out in the Praeg Glacier Valley (South Black Forest, Freiburg district) on two middle-sized, several-week rotational pastures (details in Chap. 3). Both of the grazing areas in the South Black Forest (*south slope* and *west slope*) formed a continuous pasture but were used alternatingly as several-week rotational pastures and were sub-divided. The *south slope* pasture with 10 ha and the *west slope* pasture with 8 ha were grazed alternatingly by the same group of cattle. The stocking density was 0.7 LSU ha^{-1} on the *south slope* and 0.9 LSU ha^{-1} on the *west slope*. The grazing areas were sub-divided into very large and large set stocking pastures and medium and small rotational pastures (cf. Sect. 4.5).

Because of the uneven height situation, varying weather and vegetation growth conditions as well as the different stocking densities, driving the cattle on and off the areas took place at different times. Similarly, the duration of grazing was of different lengths on the different pastures. The different grazing areas were divided according to size and grazing procedure and compared in the analyses:

- Very large set stocking: 37 and 50 ha, continuous grazing over the whole grazing period (*Ellenbogen*, *Lichtenau*);
- Large set stocking: 20 and 25 ha, continuous grazing over the whole grazing period (*Rotenhauck*, *Hemschenberg*);
- Medium rotational pasture: 8 and 10 ha, grazing over several weeks (*south slope*, *west slope*);
- Small rotational pasture: 5 and 7 ha, grazing over several days (*Rotenhauck-R*, *Ellenbogen-R*).

Behavioral Observations

Behavioral observations were carried out for all investigation areas. The behavioral-ecological investigations took place on the set stocking pastures in the vegetation periods in 2001 and 2002, and on the rotational pastures in the vegetation periods 2001 and 2003.

For the quantitative recording of the behavior of mammals, different methods have been suggested (Altmann 1974; Kotrschal 2000; Martin and Bateson 1986; Wehnelt and Beyer 2002). The method of '*ad libitum* sampling' was used for test observations to work out an ethogram for particular questions. *Ad libitum* sampling gives an overview of the whole behavior repertoire and data is systematically recorded without restriction. For the observation of different size groups of cattle on pastures of different sizes, the method known as time sampling as a variant of scan sampling was selected. For the scan sampling method, the behavior parameters of a group of animals are recorded at regular time intervals (time sampling) (Altmann 1974; Kotrschal 2000; Martin and Bateson 1986; Wehnelt and Beyer 2002). Because of the periodical recording, very long time series are possible even in very large-scale areas with alternating locations.

Because of the different numbers of animals in the individual herds, 5 focus animals per herd were selected in each case for a standardized data collection. The focus animals showed no significant deviation from the general behavior of the herd. Cattle in a herd behave similarly to each other as individual animals adapt to the behavior of the others (Sambraus 1978). The observation series took place at the same time each day. Because the set stocking pasture at *Rotenhauck* was structurally very varied and difficult to see as a whole, an animal was fit with a transmitter and located via telemetry.

Each day, the cattle group to be observed was given 30 min before the start of observations to get used to the presence of the observer. During observations, as large a distance as possible was maintained and where possible, a hiding place was used.

The different categories of behavior – grazing, browsing of woody vegetation, drinking, walking, herd movement, standing (including excreting dung and urine), lying, social behavior and grooming behavior – were recorded individually and summarized into the behavior patterns feeding, locomotion and inactivity, which are relevant for the effects on the area. The feeding activity category included grazing vegetation on the pasture, browsing of branches and leaves of woody vegetation as well as drinking out of troughs, streams and individual wet sites. Locomotion was differentiated with the movement of individual animals, short duration walking and the movement of the entire herd from one location to another. Inactivity is equated with resting phases of the animals, in which they rest standing or lying and ruminate. In grooming behavior, the cattle carry out grooming by rubbing against woody vegetation or licking their skin. Social behavior refers to interactions between cattle with body contact, for example, mutual grooming (rubbing, licking) or playing.

For the recording of data in the Thuringian Rhoen, three observation blocks were carried out spread over the whole vegetation period and in each case during daylight hours in spring/early summer, high summer and late summer. The observation periods were set up according to the times of driving the cattle out for the rotational pasture where the animals remained from only 4–8 days, depending on available nutrition. In the investigation year 2001 in the Thuringian Rhoen, six cattle groups were observed alternatingly. A seasonal observation block comprised twelve days and observations started about one month after the cattle were driven out to pasture. An observation run in the Thuringian Rhoen covered the time from 7:00 until 20:00 over a period of twelve days. For each recording day, the relevant parameters for the focus animals in two herds were alternatingly recorded every ten minutes, in each case two times for a period of 2.5 h (Table 6.1). On the following days, the herds were exchanged so that on the fourth day, the second run could take place. Here, the observation periods for both herds on the first run were swapped around compared to the first run. This method ensured that all six herds could be studied over the whole investigation period under similar weather conditions and still allowed for observations over the whole daily period. The duration of observation amounted to 20 h per herd and observation block with in each case 120 recordings. This resulted in a total of 360 observation hours for the six herds with 2160 datasets over the whole grazing period.

The behavior observations of the cattle group in the South Black Forest (2001 investigation year) comprised in each case an observation block in high summer and late summer each with 8 observation days. The high summer run took place on the *south slope* pasture and the late summer run on the *west slope* pasture. The cattle group in

Table 6.1. Definitions of the recorded behavior parameters

Behavior parameter	Definition of the behavior parameter
Feeding	
Grazing	Grazing vegetation on the pastures
Browsing	Browsing branches and leaves of woody vegetation on the pasture
Drinking	Drinking water from troughs, streams and wet areas on the pasture
Locomotion	
Walking	Short-period slow forward movement (several seconds) without grazing – individual animals at the herd's location
Herd movement	Longer uninterrupted forward movement (up to several minutes) without grazing by the whole herd in changing location
Inactivity	
Standing	Standing still
Lying	Procumbent
Grooming behavior	Rubbing on trees or objects, rubbing or licking skin
Social behavior	Positive and negative interactions between two or more animals with body contact (social grooming, playing, ranking order behavior)

high summer consisted of 11 animals and in late summer of 13 animals. The behavior parameters for all animals were alternately recorded daily in ten-minute intervals in the period from 8:00 until 13:30 and from 13:30 until 19:00 (in each case, 5.5 hours per day (h d^{-1})) (Table 6.2). This resulted in a total of 512 datasets from 88 observation hours over the whole observation period.

In the second year of investigation (2002), the behavior of the cattle on the set stocking pastures was investigated using recordings of exact locations on the pasture which were visited, and the same was carried out for the rotational stocking pastures in the third year (2003). To allow for longer observation periods in both cases, the investigations of set and rotational stocking were spread separately over two years (Table 6.3). For each pasture, the observation period selected was a continuous 12 h (7:30–19:30) with recording intervals of 15 min. In view of the analysis benefits of large-scale, the *Lichtenau* area was enlarged to 50 ha and occupied with a stocking density of 1 LSU ha^{-1}. The set stocking pastures *Hemschenberg*, *Rotenhauck* and *Ellenbogen* retained the stocking density of the previous year. The observation periods for the set stocking pastures were in each case, four consecutive days per pasture during the seasons spring/early summer, high summer and late summer. The observations were commenced in each case a week into grazing to allow the animals to become familiar with each other and with the pasture. For the whole observation period on the set stocking pasture in 2002, there were 576 observation hours and 2 304 datasets. The observation periods for the rotational pastures comprised in each case only three consecutive days per pasture because of the periodically short grazing duration of 4–8 d. The total observation period

Table 6.2. Arrangement of observation times, Thuringian Rhoen and South Black Forest 2001 (times shown using 24-hour clock). Set stocking pasture: *HB:* Hemschenberg, *LA:* Lichtenau; *RH:* Rotenhauk, *EB:* Ellenbogen; rotational pasture: *RHR:* Rotenhauk, *EBR:* Ellenbogen; common grazing, South Black Forest: *SH:* south slope, *WH:* west slope

Pasture	Day 1+7/ Day 1+5^{S}	Day 2+8/ Day 2+6^{S}	Day 3+9/ Day 3+7^{S}	Day 4+10/ Day 4+8^{S}	Day 5+11	Day 6+12
HB	7:00– 9:20 14:00–16:20			10:30–12:50 17:30–19:50		
LA	10:30–12:50 17:30–19:50			7:00– 9:20 14:00–16:20		
RH		7:00– 9:20 14:00–16:20			10:30–12:50 17:30–19:50	
EB		10:30–12:50 17:30–19:50			7:00– 9:20 14:00–16:20	
RHR			7:00– 9:20 14:00–16:20			10:30–12:50 17:30–19:50
EBR			10:30–12:50 17:30–19:50			7:00– 9:20 14:00–16:20
SH	8:00–13:20	13:30–18:50	8:00–13:20	13:30–18:50		
WH	8:00–13:20	13:30–18:50	8:00–13:20	13:20–18:50		

Table 6.3.
Arrangement of observation times, Thuringian Rhoen, 2002/2003

Year	Pasture	Week 1	Week 2	Week 3	Week 4
2002	HB	7:30–19:15			
	LA		7:30–19:15		
	RH			7:30–19:15	
	EB				7:30–19:15
2003	RHR	7:30–19:15			
	EBR		7:30–19:15		

for 2003 on the rotational pastures amounted to 432 observation hours with 1728 datasets. Observation commenced one day after arrival. The cattle had already formed into clear herd groups over previous grazing times and during driving. Each seasonal observation block for the 6 set stocking pastures was 16 days and for both of the rotational pastures, 6 days.

Analysis of Habitat Use

Over the same time period and on the same areas used for the observation of behavior, the habitat use of the cattle was studied on the individual pastures in the first year of investigation (2001). For the collection of data, binoculars and unreferenced aerial photographs were used. An exact assignment to the habitat types was established through direct observation. In addition, the habitats available to the cattle were subdivided into the functional units *open land*, *proximity to woody vegetation*, *water supply*, *path* and *rest stations*. The open land category included all the vegetation free of woody species. The category ‘proximity to woody vegetation’ refers to a cattle visit in the immediate vicinity of woody vegetation (including 5 m edge strips, subtracted from open land). Water supplies were available over most of the areas and on two areas (*Lichtenau* and *west slope*), there were natural supplies in the form of access points to fenced streams. For paths, the cattle tracks arising over long years of grazing were mapped. For rest stations, the areas were designated which were repeatedly used as resting places during the observations.

For each habitat visit, the established type of behavior was recorded in each case. For the analysis of the habitat use, preference indexes according to Ivlev (Ivlev 1961; Jacobs 1974) were calculated. The Ivlevian preference index e is calculated from the percentage frequency of use r and the proportional area percentage p using the equation $e = (r - p) / (r + p)$. It varies between the values +1 and −1 and represents preferences (+1), neutrality (0) and avoidance (−1) of a particular location independent of the availability on the remaining area.

Analysis of Vegetation Use

The analysis of the vegetation preference was based on vegetation mapping carried out previously and the vegetation visits of the cattle were determined through direct observations. The vegetation types were divided into *fresh grassland*, *thin grassland*, *mountain pasture grassland*, *mesophilic grassland*, *ruderal grassland*, *ruderal meadow* and *wet land*. The vegetation structure was divided into three structural classes (short, patchy and hardly grazed) (cf. Sect. 6.2).

For all vegetation types, the frequency of grazing was determined in order to analyze the associated impacts on the vegetation structure. The effects of grazing on the pastures of the Turingian Rhoen were analyzed in relation to vegetation structure maps following the observation runs (Sect. 6.2). In addition, the vegetation use was differentiated according to individual cattle pastures and the seasons early summer, high summer and late summer. The vegetation use analysis was carried out using the selectivity index E. This describes the feeding preferences of the cattle in relation to the availability of nutrition, with reference to the degree of cover of the preferred vegetation types. It is calculated similarly to Ivlev’s preference index for the feeding time Pa and the degree of cover of the preferred vegetation type Cv using the equation $E = (Pa - Cv) / (Pa + Cv)$. The values vary between +1 and −1, where values from −0.25 to +0.25 describe a balanced grazing of the nutritional availability.

Determination of Locations Visited

The exact locations of cattle visits on the set stocking and rotational pastures of the Thuringian Rhoen (2002/2003) were determined using mapping analyses. The mapping was based on aerial photographs (digitized orthophotos, resolution about 0.5 m, taken in 1997). Temporal and spatial movement patterns were also analyzed.

In addition, the coordinates of the observation points were located using a D-GPS equipment. From these locations, the relevant animals situated in the center of the herd were sighted and recorded with a 'Geovid' telescopic device from the company Leica. From the located observation points, the relevant positions of the cattle were determined using ArcView and the distance traveled over time by the cattle was calculated. The focus of the investigation was on the frequency of visits to particular places in order to draw conclusions about vegetation preferences. It was also on analyzing the locomotion behavior of cattle per unit of time with reference to the traveled stretches. With this calculation basis, the course of movements and the traveled distances per herd can be determined for each day. For all of the investigated pastures, the grazing intensity as determined at the end of the grazing period was represented. This uses grid squares and the relevant visit frequencies determined for the cattle to describe the intensity of use over the area for the whole observation period.

For an analysis of the herd distribution, the extreme four corner points for the edges of the herd (front, back, left and right) were determined using sighting equipment at defined observation times. The observation recordings took place over two days in hourly intervals from 6:00 to 21:00 in June and from 6:30 to 20:30 in August, in consideration of obtaining similar light conditions (sunrise and sunset times). The spatial distribution of the herd was calculated and schematically represented with ArcView. This gave the spatial-temporal distribution pattern of the herd over each day. With the simultaneous recording of the behavior types of the herd, temporal and spatial movement patterns could be analyzed. For the calculation of herd locomotion over the day, again, the animal situated in the center of the herd was determined in order to obtain an intersection with data from ArcView. With ArcView, an area distribution of the herd can be schematically represented.

The statistical evaluation of the data was carried out with the programs Excel (percent), SPSS (median) and SsS (*G*-test). The individual pastures were compared with reference to the three behavior patterns using the *G*-test (significance level $p \leq 0.05$). Using the Bonferroni correction, the significance level could be lowered to $p \leq 0.005$ so that through the number of pair comparisons carried out, the probability of getting a significant result could be realistically raised. The evaluations were carried out separately for the areas (Thuringian Rhoen and South Black Forest).

6.1.3
Results

Behavior Activity

Using the observed frequencies of the types of behavior, the spatial-temporal activities of the cattle could be compared, both between the individual pastures and also between the four grazing procedures which took place in 2001. For the individual pastures, the time proportions of the behavior elements were determined (Fig. 6.1).

In the comparison of the individual pastures, in 6 of the 8 investigated pastures, feeding took up the highest proportion of time for the various behavior patterns (Fig. 6.1). On the four large set stocking pastures of the Thuringian Rhoen, the proportion of feeding time amounted to 52–62% and the proportion of inactive phases ranged between 31–42%. On both of the small rotational pastures, on the other hand, feeding accounted for only 45% and 32% allowing inactivity to make up 43% and 60% respectively. In the South Black Forest, the inactivity phase for cattle on the *south slope* took up the highest proportion with 50% of the time. On the *west slope*, however, inactivity was lower at 32% in favor of feeding at 63%. The lowest proportion of recordings was for locomotion and the size of the area made no significant difference for this element. The most frequent movement was recorded on both of the areas of the *Ellenbogen* (set stocking and rotation). The proportion of time spent for locomotion for all areas was between 5% and 17%.

With respect to locomotion, the significance level between the individual pastures was very differently distributed (Table 6.4) but still allows conclusions to be drawn about the influence of area size on the proportion of time spent on movement. The set stocking pastures *Hemschenberg* and *Rotenhauck* ($p = 0.000$) are characterized by a clearly higher proportion of movement compared to the rotational pastures (Thuringia Rhoen), and for the set stocking pastures *Lichtenau* and *Ellenbogen*. The differences are significant and marginally significant respectively to the rotational pastures

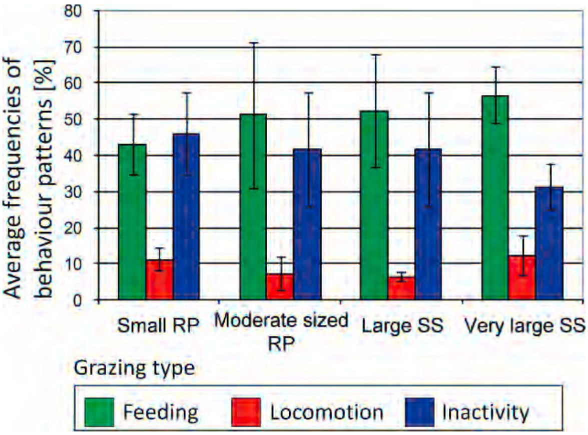


Fig. 6.1. Average percentage frequencies of behavior patterns of the cattle for different grazing systems ($n = 8$ pastures) within the whole observation period, Thuringian Rhoen and South Black Forest, 2001. $n = 1232$. *SS:* Set stocking, *RP:* rotational pasture

Table 6.4. Differences in the proportion of locomotion time in a comparison of the eight pastures (Thuringian Rhoen and South Black Forest, 2001) (significance level $p \leq 0.005$, [a] Significant)

Pasture	Lichtenau	Ellenbogen	Hemschenberg	Rotenhauck	Ellenbogen-U	South slope
Lichtenau	–	–	–	–	–	–
Ellenbogen	<0.001[a]	–	–	–	–	–
Hemschenberg	0.033	<0.001[a]	–	–	–	–
Rotenhauck	0.073	<0.001[a]	0.740	–	–	–
Ellenbogen-R	0.006	<0.001[a]	<0.001[a]	<0.001[a]	–	–
Rotenhauck-R	0.004[a]	<0.001[a]	<0.001[a]	<0.001[a]	<0.001[a]	–
West slope	–	–	–	–	–	<0.001[a]

Rotenhauck-R ($p = 0.004$; $p = 0.000$) and *Ellenbogen-R* ($p = 0.006$; $p = 0.000$). On the *south slope* pasture (South Black Forest), the proportion of locomotion time was significantly higher than on the *west slope* pasture.

Feeding activity on the largest area, the set stocking pasture *Lichtenau*, was significantly the most frequent occurrence compared to all other pastures of the Thuringian Rhoen ($p = 0.000$). Between the other three set stocking pastures and between both of the rotational pastures of the Thuringian Rhoen, there were no significant differences (Table 6.5), feeding on the set stocking pastures therefore took up a significantly greater proportion than on the rotational pastures (Thuringian Rhoen). Between all other combinations of pasture, the frequency of feeding was observed to be significantly different. On the *west slope* pasture (South Black Forest), the proportion of feeding was significantly higher than on the *south slope* pasture.

The proportion of time for inactivity on both of the very large set stocking pastures (*Lichtenau*, *Ellenbogen*) was significantly lower ($p < 0.001$, Table 6.6) compared to both the large set stocking pastures (*Hemschenberg*, *Rotenhauck*) and also the two rotational pastures (Thuringian Rhoen). Here too, the influence of area size was clear. Both of the

Table 6.5. Differences in the proportion of feeding time in a comparison of the eight pastures (Thuringian Rhoen and South Black Forest, 2001) (significance level $p \leq 0.005$, ^{a} Significant)

Pasture	Lichtenau	Ellenbogen	Hemschenberg	Rotenhauck	Ellenbogen-R	South slope
Lichtenau	–	–	–	–	–	–
Ellenbogen	<0.001[a]	–	–	–	–	–
Hemschenberg	<0.001[a]	0.641	–	–	–	–
Rotenhauck	<0.001[a]	0.871	0.529	–	–	–
Ellenbogen-R	<0.001[a]	<0.001[a]	0.008	0.001[a]	–	–
Rotenhauck-R	<0.001[a]	<0.001[a]	0.001[a]	<0.001[a]	0.082	–
West slope	–	–	–	–	–	<0.001[a]

Table 6.6. Differences in the proportion of inactivity in a comparison of the eight pastures (Thuringian Rhoen and South Black Forest, 2001) (significance level $p \leq 0.005$, ^{a} Significant)

Pasture	Lichtenau	Ellenbogen	Hemschenberg	Rotenhauck	Ellenbogen-R	South slope
Lichtenau	–	–	–	–	–	–
Ellenbogen	0.399	–	–	–	–	–
Hemschenberg	<0.001[a]	<0.001[a]	–	–	–	–
Rotenhauck	<0.001[a]	<0.001[a]	0.937	–	–	–
Ellenbogen-R	<0.001[a]	<0.001[a]	0.421	0.468	–	–
Rotenhauck-R	<0.001[a]	<0.001[a]	<0.001[a]	<0.001[a]	0.006	–
West slope	–	–	–	–	–	<0.001[a]

Table 6.7. Number and percentage values of behavior patterns for cattle on different pasture types within the whole observation time, Thuringian Rhoen and South Black Forest 2001, 2002 and 2003. *SS:* Set stocking pasture, *RP:* rotational pasture

Year	Pasture type/ behavior pattern	Small RP		Medium RP		Large SS		Very large SS	
		Number	%	Number	%	Number	%	Number	%
2001	Feeding	1528	43.1	3401	52.1	1843	52.3	2018	56.8
	Locomotion	394	11.1	455	7.0	227	6.4	435	12.2
	Inactivity	1624	45.8	2674	40.9	1455	41.3	1102	31.0
2002	Feeding	–	–	–	–	2577	44.7	2435	42.3
	Locomotion	–	–	–	–	428	7.4	540	9.4
	Inactivity	–	–	–	–	2755	47.8	2785	48.4
2003	Feeding	1820	42.1	–	–	–	–	–	–
	Locomotion	388	9.0	–	–	–	–	–	–
	Inactivity	2112	48.9	–	–	–	–	–	–

large set stocking pastures were characterized by a significantly lower inactivity compared to the rotational pasture *Rotenhauck-R*, but not to the rotational pasture *Ellenbogen-R*. On the *south slope* pasture (South Black Forest), inactivity represented a significantly higher proportion ($p = 0.000$) than on the *west slope* pasture.

With respect to the 4 categories of pasture size, the proportion of feeding on the small rotational pastures was 43% of the time, on the medium-sized rotational pastures and large set stocking pastures, 52% and on the very large set stocking pasture, 57%. Also for inactivity (particularly standing and lying), a gradient from the small to the large pastures is recognizable, although in reverse order. On the small rotational pastures, inactivity amounted to 46%, on the medium-sized rotational pastures and the large set stocking pastures, 41% in each case and on the very large set stocking pastures, 31%. Locomotion took up 11% of time on the small and 7% on the large rotational pastures, 6% on the large and 12% of all recorded behavior types on the very large set stocking pastures, although these values do not allow for conclusions about the influence of pasture size (Table 6.7).

Seasonally-Dependent Behavior

The recorded patterns of behavior were studied to find out whether they were differently represented over the periods of year – early summer, high summer and late summer (Table 6.8). In 2001, there were significant differences here for the cattle on the *RH* set stocking pasture between two periods. The feeding time was significantly lower in high summer than in late summer ($p < 0.05$, polynomial test). In contrast to this, the proportion for inactivity in high summer was significantly higher than in late summer ($p < 0.05$). All other cattle groups indicated no significant behavioral differences between the year periods. The study of the proportion of behavior pattern in the years 2002 (set stocking pastures) and 2003 (rotational pastures) similarly gave no significant differ-

Table 6.8. Seasonal time budget for behavior patterns in %, Thuringian Rhoen 2001 and 2002/2003 and South Black Forest 2001. Early summer: April/May, high summer: June/July, late summer: August/September. Rhoen: n = 2160 (2001), 2340 (2002), 1728 (2003); South Black Forest: n = 512 (2001)

Pasture	Season/ behavior	2001			2002/2003		
		Early summer	Mid-summer	Late summer	Early summer	Mid-summer	Late summer
LA	Feeding	60.2	54.0	67.5	49.9	45.5	53.7
	Locomotion	6.0	7.8	10.3	9.8	5.7	11.0
	Inactivity	33.7	38.2	22.1	40.7	49.0	36.2
EB	Feeding	44.5	53.7	59.8	38.3	38.1	51.6
	Locomotion	21.4	12.7	15.8	12.2	9.2	12.9
	Inactivity	34.1	33.7	24.3	49.7	52.7	35.8
HB	Feeding	42.0	56.0	57.3	50.5	35.4	42.1
	Locomotion	5.3	7.5	6.2	10.8	4.2	8.8
	Inactivity	52.8	36.5	36.5	40.1	61.0	50.0
RH	Feeding	44.4	34.3	78.5	36.0	46.8	58.2
	Locomotion	8.4	5.0	6.2	10.5	4.4	7.7
	Inactivity	47.2	60.7	15.4	53.9	48.8	34.6
RH-RP	Locomotion	8.5	10.8	14.2	11.4	7.2	6.8
	Inactivity	54.0	40.7	35.3	51.7	44.6	42.1
	Feeding	33.2	36.0	52.9	37,9	34.0	44.2
	Locomotion	7.3	10.5	15.3	9.2	7.9	11.4
	Inactivity	59.9	53.5	31.8	53.2	58.3	44.7
Southern slope Black Forest	Feeding	–	21.7	57.2	–	–	–
	Locomotion	–	14.1	5.1	–	–	–
	Inactivity	–	64.2	37.7	–	–	–
Western slope Black Forest	Feeding	–	67.7	58.2	–	–	–
	Locomotion		5.1	4.5	–	–	–
	Inactivity		27.3	37.3	–	–	–

ences between the year periods (polynomial test). For individual comparisons of the absolute frequencies (2002/2003) with respect to the investigations in the course of the seasons, the two rotational pastures and the four set stocking pastures were compared (Table 6.9). Here, the values which show a significantly higher proportion of time for the particular behavior pattern for the rotational pastures than for the set stocking pastures are marked with a '+' sign, and for values with a lower time budget, a '–' sign.

Table 6.9. Error probabilities p (significance level $\alpha \leq 0.013^{a}$ and $\alpha \leq 0.025^{b}$, *G*-test, Bonferroni corrected) with respect to behavior patterns in the course of the year between set and rotational stocking, Thuringian Rhoen 2002/2003. '+': more frequently, '–': less frequently

Pasture	Season/ behavior	RH-RP			EB-RP		
		Early summer	Mid-summer	Late summer	Early summer	Mid-summer	Late summer
RH	Feeding	0.487	0.003^{a}–	$<0.001^{a}$–	0.601	0.186	0.011^{a}–
	Locomotion	0.247	$<0.001^{a}$+	$<0.001^{a}$+	0.875	0.005^{a}+	0.760
	Inactivity	0.942	0.157	$<0.001^{a}$+	0.610	0.026	0.003^{a}+
HB	Feeding	0.001^{a}–	0.857	0.353	$<0.001^{a}$–	$<0.001^{a}$+	0.004^{a}+
	Locomotion	0.089	0.011^{a}+	0.052	0.701	0.039	0.337
	Inactivity	$<0.001^{a}$+	0.495	0.079	$<0.001^{a}$+	$<0.001^{a}$–	$0.015^{(*)}$–
EB	Feeding	0.544	0.822	0.294	0.664	$<0.001^{a}$–	0.390
	Locomotion	0.105	0.704	0.374	0.758	0.922	0.044
	Inactivity	0.827	0.972	0.522	0.826	$<0.001^{a}$–	0.968
LA	Feeding	0.011^{a}–	$<0.001^{a}$–	0.312	0.006^{a}–	0.760	0.368
	Locomotion	0.054	0.008^{a}+	0.875	0.542	0.029	0.006^{a}–
	Inactivity	$<0.001^{a}$+	0.010^{a}+	0.004^{a}+	0.004^{a}+	0.279	0.775

Habitat Use

The patterns of behavior were recorded during the visits to the listed habitat types. The highest proportion of time for feeding (92%) was spent by the cattle on all pastures (Thuringian Rhoen and South Black Forest) during the whole observation time on the open vegetation areas which were free of woody species. 4.6% of feeding time took place near to woody species, 0.9% at water supply places and 2.5% at rest stations. Also for locomotion and inactivity, the largest proportion of time was spent on open areas (54.6%). Cattle tracks were used over 33.6% of the recorded time. These followed mainly linear structures such as hedges, woodland edges and fences. Along edges of woods etc. the cattle moved 11.7% of the time. They spent 55.1% of the time for rest phases on open land. 29.1% was spent seeking well-established rest stations and 13.3% on proximity to woody vegetation. The figure of 2.5% for inactivity at water supply places is accounted for by time standing to take in water. In interpreting the results, however, it should not be forgotten that the observations were only during daylight hours.

For the four pasture types, the median value was calculated (Table 6.10) and preferred or avoided use was calculated using the preference index e (Fig. 6.2). Of all available habitat types, the open land areas of the small rotational pastures were used 66% of the time and the medium rotational pastures 70%. The preference indexes for the small and medium rotational pastures indicated preferred uses of the woodless vegetation areas (open land). On very large set stocking pastures, on the other hand,

Table 6.10. Number, median and percentage values for use frequencies of available habitat types for all investigated pastures over the whole observation time, Thuringian Rhoen and South Black Forest 2001. The percentages in the second part of the table add to 100% per pasture type in each case; Rhoen: $n = 2160$, Southern Black Forest: $n = 512$

Pasture type/ habitat type	Small RP		Medium size RP		Large SS		Very large SS	
	Median	Quartile	Median	Quartile	Median	Quartile	Median	Quartile
Open land	89.0	37.75 219.75	230.5	58.5 727.5	164.5	31.5 243.75	138.5	43 305.25
Wood proximity	12.0	3.0 16.25	20.0	6.25 69.5	10.5	3.75 31.25	5.5	1.75 13.25
Water supply	2.5	0 6.0	0	0 7.5	0	0 3.0	0	0 3.75
Track	0	0 15.75	0	0 21.25	0	0 1.25	0	0 10.5
Rest station	0	0 56.25	55.5	0.5 223.75	0	0 0	0	0 1
	Number	%	Number	%	Number	%	Number	%
Open land	2331	65.9	4547	69.4	2852	80.9	2982	83.9
Near woody veg.	363	10.3	431	6.6	459	13.0	234	6.6
Water supply	93	2.6	76	1.2	29	0.8	51	1.4
Track	118	3.3	117	2.7	45	1.3	169	4.8
Rest station	630	17.8	1325	20.2	140	4.0	119	3.3

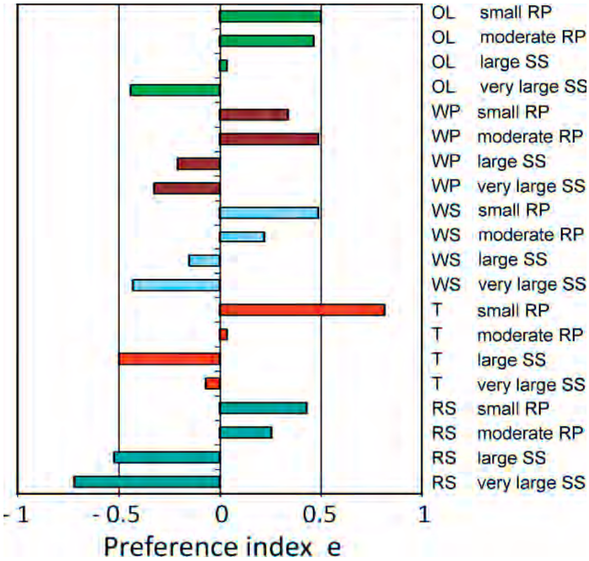


Fig. 6.2. Preference index of habitat types used by the cattle in different grazing systems, Thuringian Rhoen and Southern Black Forest (2001). (*OL:* Open land, *WP:* wood proximity, *WS:* water supply, *T:* track, *RS:* rest station)

Table 6.11. Error probabilities (significance level $p \leq 0.05$) in a comparison of the habitat use of rotational pastures Rotenhauck-RP: *RH-RP*, Ellenbogen-RP: *EB-RP*) and set stocking pastures (Rotenhauck: *RH*, Ellenbogen: *EB*), Thuringian Rhoen (2001). $n = 2160$. [a] Significant, [b] marginally significant, *n.s.:* not significant; use comparisons: '>': more frequently used, '<': less frequently used

Pasture/ habitat types	Rotenhauck-RP – Rotenhauck	Use comparison	Ellenbogen-RP – Ellenbogen	Use comparison
Open land	<0.001[a]	RH-RP < RH	<0.001[a]	EB-RP < EB
Near woody veg.	0.854	n.s.	0.028[a]	EB-RP > EB
Water supply	<0.001[a]	RH-RP > RH	<0.001[a]	EB-RP < EB
Track	0.004[a]	RH-RP > RH	<0.001[a]	EB-RP < EB
Rest station	<0.001[a]	RH-RP > RH	<0.001[a]	EB-RP > EB

the open areas tended to be avoided by the cattle and on large set stocking pastures were used neutrally. Regarding visits to areas of woody vegetation, the indexes revealed a preference for visits to woody areas on the small and medium rotational pastures. A tendency to avoid these in comparison to other habitats was evident on the large and very large set stocking pastures. The drinking places and the resting stations indicated a gradient from small (preferred) to very large pastures (visited more seldom). Existing paths were preferred the most on small rotational pastures and the least on large set stocking pastures.

The habitat use of the cattle on the set stock pastures Rotenhauck and Ellenbogen were each compared with the adjacent rotational pastures Rotenhauck-RP and Ellenbogen-RP. The pasture areas lying adjacent to each other have similar local conditions with similar grazing structures and this therefore validates the significance of the investigation (Table 6.11). The open land area was used significantly less by the cattle in both rotational pastures compared to the set stocking pastures ($p < 0.001$). The proximity to woody vegetation was only used more frequently on the rotational pasture Ellenbogen-RP than on the adjoining set stocking pasture ($p < 0.05$). Water supply and existing tracks were used significantly more by the cattle of the rotational pasture Rotenhauck-RP and by the cattle of the rotational pasture Ellenbogen-RP significantly less than on the set stocking pastures ($p < 0.001$). Established rest stations, on the other hand, were in both cases used significantly more frequently ($p < 0.001$) by the cattle of the rotational pastures.

Vegetation Use

Investigations of the grazing behavior were carried out on all 6 pastures of the Thuringian Rhoen. The selectivity indexes (E) were calculated from the proportion of available vegetation types and the proportion of grazing frequencies (Fig. 6.3).The highest proportion of grazing was found to be fresh grassland with 41.6%. The proportion for mesophilic grassland is 23.1%, for thin grassland 14.6% and for mountain pasture grassland, 11.4%. Significantly lower figures were found for ruderal grassland (4.7%), ruderal meadows (1.6%) and wet land with only 0.2%. In the comparison of the total of all vegetation types (open land) and areas near woody vegetation, 2.7% was grazed in the latter area. The selectivity indexes indicate a balanced grazing level for fresh grassland, thin grassland, mountain pasture grassland and mesophilic grassland. The selectivity indexes for ruderal grassland indicated that there had been overgrazing. Ruderal meadows in the narrower sense and wet land were clearly undergrazed.

Locomotion Behavior

The distances covered over the course of days and seasons were analyzed using average value comparisons for the grazing processes on large and very large set stocking pastures (2002, each 4 days per grazing per season), as well as for small rotational pastures (2003, each 3 days per grazing per season) and were calculated for the periods early summer, high summer and late summer.

The cattle on the set stocking pastures covered further average distances than the cattle on the rotational pastures (Fig. 6.4). The distances covered increased with the size of the pasture. There was a marginally significant correlation between the distances covered each day and the size of the pasture ($p = 0.067$; $r^2 = 0.61$, linear regression analysis). The longest distances covered each day were by the heifers of the set

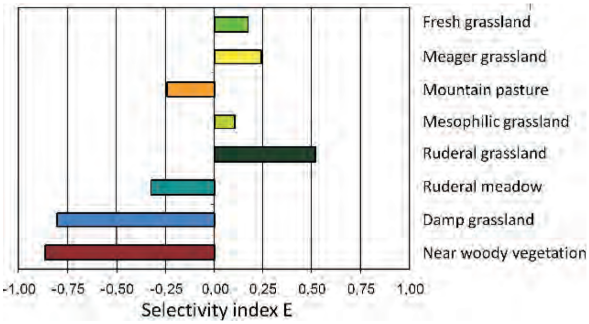


Fig. 6.3.
Selectivity index of vegetation areas used for grazing including areas near woody vegetation for all investigated pastures of the Thuringian Rhoen (2001)

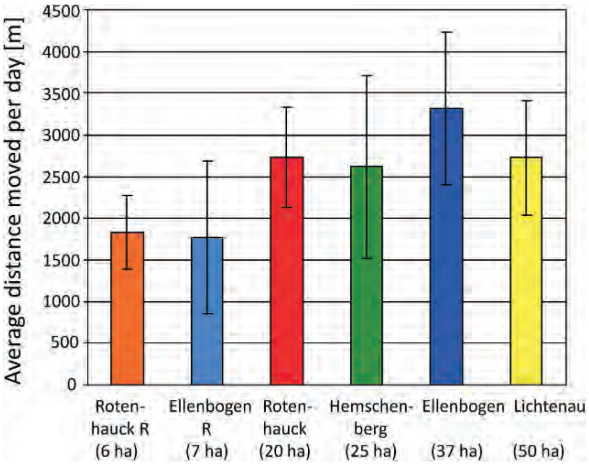


Fig. 6.4.
Average distances per day (m) over the whole observation time on pastures of the Thuringian Rhoen, arranged according to size, 2002/2003. $n = 576$ (set stocking pastures); 432 (rotational pastures)

stocking pasture *EB* with 3 316 m per day. The heifers of the set stocking pasture *RH* showed medium distances with values of 2 730 m. For the suckler cows of the set stocking pasture *LA*, the figure was 2 727 m and for those on the set stocking pasture *HB*, 2 616 m per observation day. On the rotational pasture, the daily distances of the heifers averaged 1 830 m on the pasture *RH-RP* and 1 765 m on the pasture *EB-RP*.

Fig. 6.5.
Average distances covered, over different-sized pastures, Thuringian Rhoen 2002/2003. $n = 512$ (*RP:* rotational pasture)/720 (*SS:* set stocking)

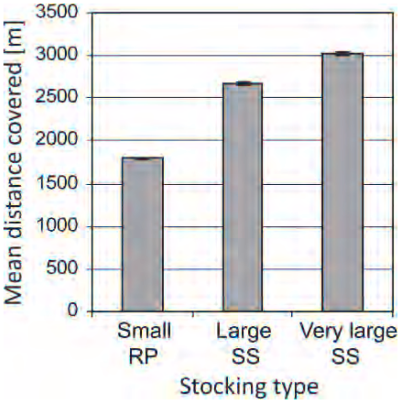


Fig. 6.6.
Average distances covered over seasons, Thuringian Rhoen 2002/2003. $n = 512$ (*RP:* rotational pasture)/720 (*SS:* set stocking)

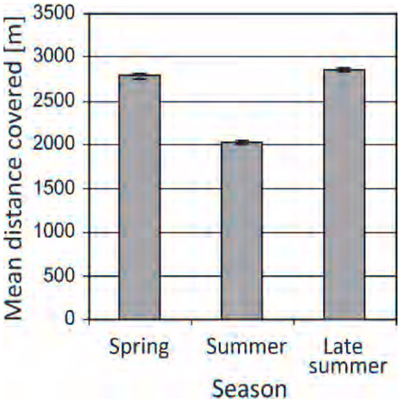
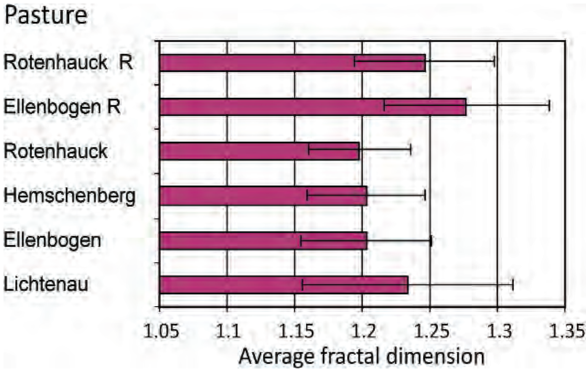


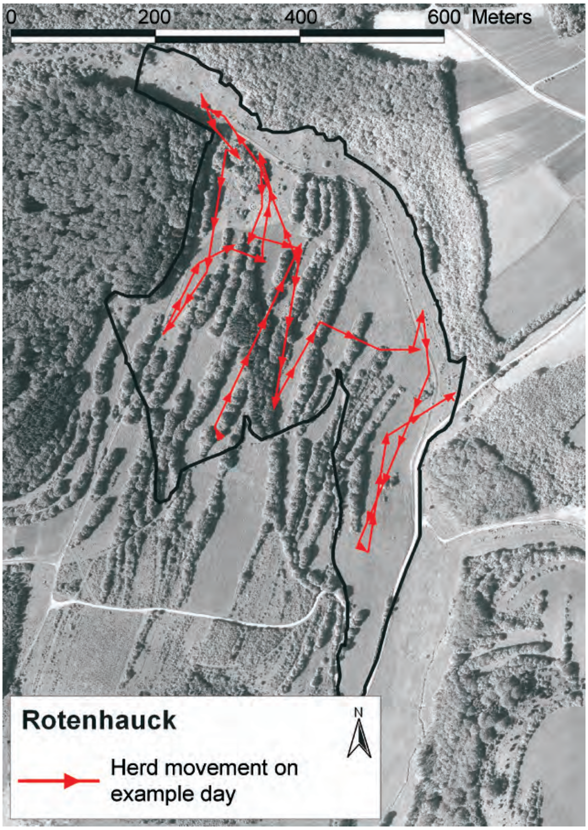
Fig. 6.7.
Average fractal dimensions over the whole observation time, Thuringian Rhoen (2002/2003). $n = 576$ (set stocking); 432 (rotational pasture)



Over the different pastures, there was a gradual increase in average distance traveled, from the small rotational pastures with 1 798 m to the large and very large set stocking pastures (2 673 m and 3 022 m respectively) (Fig. 6.5). In a comparison of the cattle breeds, the longest distances traveled were for heifers on the set stocking pastures (*RH*, *EB*), followed by the suckler cows on the set stocking pastures (*HB*, *LA*). The heifers of the rotational pastures (*RH-RP*, *EB-RP*) covered the least distances. Seasonal comparisons (total of all pastures per season) based on the distances covered gave the greatest locomotion in late summer with 2 868 m and the lowest in high summer with 2 025 m (Fig. 6.6).

For all 6 pastures, the direction of movement of the cattle was calculated using the average fractal dimensions, of which the values between 1 and 2 represented a directional and straight or a non-directional and not straight movement (Fig. 6.7). All of the observed groups of cattle showed straight, that is, directed forward movement patterns in the course of their locomotion. More stable values towards directed movements were realized by the cattle on the set stocking pastures. The values of the fractal dimensions of the cattle on the rotational pastures were slightly higher and therefore tended towards a non-straight and non-directional forward movement. For the various cattle groups, a circular movement was observed over the course of the day (Fig. 6.8).

Fig. 6.8.
Circular herd movements from an example day on the *Rotenhauck* set stocking pasture, Thuringian Rhoen (late summer 2002)



6.1.4
Discussion

Behavior Activity

The activity rhythm of the cattle follows a regular alternation between periods of grazing, grooming behavior and rest phases, and this repeats three to five times daily (Rist and Schragel 1993). This pattern was confirmed on all investigated areas without exception. The gradual increase in feeding time (mainly through grazing) and the gradual decrease in activity from small rotational pastures to very large set stocking pastures are an indicator that the size of the area has an influence on the activities. Investigations on cattle behavior in the New Forest (37 500 ha; Tubbs 1997) showed that over the course of the day, 60% of time was spent on feeding, 21% on locomotion and 24% on inactivity. These values are very close to the ones found for very large set stocking pastures in this study (57% feeding, 12% locomotion, 31% inactivity). Studies of wild cattle (free living European bison) by Cabon-Raczynska et al. (1987) resulted in 60% feeding, 8% on locomotion and 32% on inactivity. Studies of bison in enclosures gave results for feeding of 46%, (van den Brink 1980), 24, 27 and 33% (Popp 1999), 30% (Pucek 1986) and 18% (Vajner 1980), for locomotion, 2.4% and 6% (Popp 1999) and 10% (Pucek 1986). For inactivity, the values are 28% (van den Brink 1980), 26, 45 and 46% (Popp 1999), 60% (Pucek 1986) and 41% (Vajner 1980). These values are close to those for rotational pastures in this study (41/45% feeding, 11/11% locomotion, 43/48% inactivity). There are therefore similarities in the behavior of wild and domestic cattle depending on the actual method of keeping. The significance test in the comparison of set stocking and rotational pastures gave different results regarding feeding behavior and inactivity (increased feeding and less activity on set stocking pastures) but not with respect to locomotion.

Within the time budgets for behavioral elements for all observed cattle groups, most time was spent on grazing. In the Thuringian Rhoen, the proportion of grazing time in the first year of investigation was higher on set stocking pastures there than on the rotational pastures. This was not so recognizable in the second and third years. Overall, the proportion of grazing time there – between 39% and 62% – was within the figures given by other investigators. For example, observed heifers grazed for 53% of the day according to Sneva (1970). Herbel and Nelson (1966) determined proportions of 50% (Gertrudis cattle) and 47% (Herefords). Stuth (1991) deviates from these results with a finding of 90% for grazing time per day. Adams (1985) observed bulls and found that the duration of lying time was higher than for grazing. Seen on a percentage basis, the results equal those from Hancock (1953), who established grazing proportions for non-lactating cows of 44% and 55% for lactating cows. These figures are dependent on the form of keeping of the animals and not on the breed.

According to Arnold (1981), feeding activity is affected by the reproductive and physiological status of the animal. Lactating animals take up more nutrition than non-lactating ones. This is evident in longer grazing times. Although the values from Hancock (1953) agree with those for heifers (non-lactating cows) and suckler cows (lactating cows) of the Thuringian Rhoen and the South Black Forest, and suckler cow grazing on the *LA* pasture took up comparably the highest proportion in both investigation years, the differences between the cattle groups were not significant with regard to the breeds (Black Pied dairy cattle and Fleckvieh) and the form of keeping (heifers and suckler cows).

With reference to breed, these results agree with those from Arnold and Dudzinski (1978), who reported that there are only small to no differences between the different breeds in regard to grazing duration. Fischer et al. (1998) and de Vries and Schippers (1994) also found no differences between two different breeds as regards the frequency of grazing. Matthes et al. (1996) and Porzig (1987), on the other hand, found differences in breeds regarding the duration of grazing. According to Porzig (1987), these very differences in grazing behavior between Black Pied dairy cattle and Fleckvieh are particularly great and are evident in more intensive grazing by Fleckvieh. However, Porzig refers to comparative studies of milk cows under dissimilar conditions.

Browsing on woody vegetation does not normally form a significant part of cattle nutrition. In the Thuringian Rhoen, such browsing took up less than 1% and in the South Black Forest, 1% and 2% respectively of the time budget for behavioral elements. These values are in accord with those from other studies. An investigation by Gammon and Roberts (1980) found that the time spent browsing woody vegetation was less than 1% of the whole feeding time. For free-living European Bison, a browsing time of 5% spent on feeding was observed (Cabon-Raczynska et al. 1987). The investigations in the Thuringian Rhoen indicated a significantly higher browsing on woody vegetation for rotational pastures compared with set stocking. This could be connected with insufficient food availability and/or a lack of nutritious content in the vegetation because of dry weather in the third year, which is compensated for by an increased mineral intake from woody vegetation. The investigations also indicated a stronger preference for visits to areas close to woody vegetation in the rotational pastures, which could be accounted for by the search for shade because of the high temperatures. There may then be a connection between visits to trees and bushes, and browsing through 'opportunity' or 'boredom' (for grazing woody vegetation see also Sect. 5.3).

The intake of drinking water is largely dependent on weather conditions and the dry substance content of the nutrition, as well as from the live weight of the animal and the form of keeping. Sneva (1970) observed water intake on average 1.6 to 1.9 times a day. The drinking process lasts about 1–2 minutes at open water sources (Bogner and Grauvogl 1984). The animals visit water places mainly after grazing (Rist and Schragel 1993), particularly in the mornings, in the early afternoon or evenings (Fraser and Broom 1990), and they follow habitual routes (Süss and Andreae 1984). The number of drinking events is dependent on the distance to the water source as well as air temperature and the dry substance content of the plants (Hancock 1953) and it reduces with increasing distance (Sambraus 1978). From upwards of 5 km, cattle may put up with a single water intake each day (Rist and Schragel 1993). The more sources are present, the more frequently they are visited. For the whole time budget on all the investigated areas, the time spent on drinking took up only a very small proportion of between 0 and 1%. This is partly a result of the relatively short duration of the event within the observation intervals; on the other hand, fresh feed is available to the cattle day and night and this meets a large part of the water requirement.

The daily routines of cattle are determined by the rhythm of their digestion, in which feeding and periods of rest alternate with rumination (Krischke 1975). Following a period of grazing, there is a period of lying. Resting in a standing position serves as a transition to lying or takes place directly afterwards (Koch and Zeeb 1969). Resting is a vital function for cattle, which according to Arnold and Dudzinski (1978) occupies over 50% of the total time. Arnold (1981) asserts that cattle normally lie for more than 70% of their resting time. Rist and Schragel (1993) recorded a daily lying duration of 8–14 h. In the Thuringian Rhoen and the South Black Forest, standing took up 8–20% of the observed time and lying 21–28%, that is, a resting proportion of 29–48%. Herbel and Nelson (1966) determined standing times for two cattle breeds of 18% and 19%, and lying times of 19% and 20% respectively, giving very similar values. In total, the heifers on the rotational pastures in the first year spent significantly more time being inactive than on the set stocking pasture.

Hart et al. (1993) also proved for small pastures that cows spent more time resting than on larger pastures. Cattle on the pasture *SH* showed in correlation to feeding a greater level of inactivity than the cattle on the pasture *WH*. As with Stuth et al. (1987) and Walker et al. (1989), this represents a correlation with lower durations for grazing on the rotational pasture and with this, a connection between a higher resting proportion and a lower grazing proportion. Semi-wild cattle in the New Forest kept to rest phases of 24% (Tubbs 1997). During grazing, cattle move from place to place in groups in which the individual animals maintain a fixed proximity to each other (Fraser and Broom 1990). These movements in herd groups took up between 2–14% of the whole observation time for the six cattle groups in this study. Locomotion, consisting of individual and group movements, was observed significantly more frequently with 10% and 17% respectively on the set stocking pasture *EB*, compared to the other pastures. This pasture was the second-largest of all the investigated areas and was stocked with a large number of young cattle (99). It had an unusually long and narrow shape and there was only one water source. The time budget for locomotion on the other pastures was between 5–11%. These values are similar to those determined by Pucek (1986) and Cabon-Raczynska et al. (1987) for free-living European Bison (10 and 8%). Investigations by Tubbs (1997) in the New Forest even gave 21% for locomotion.

For the physical well-being of the cattle, grooming behavior, particularly skin care, is particularly important (Sambraus 1978; Rist and Schragel 1993). Cattle groom and clean the surface layer of skin and hair using their tongues, horns and hooves (Reinhardt and Reinhardt 1981); however, they use other means such as trees, shrubs or posts. Grooming behavior is mainly carried out in periods between grazing and lying and consists of three to four licking phases per day, according to Bogner and Grauvogl (1984). Buchholtz (1988) reports on social hierarchies characterized by social interactions. During the observations, social grooming was often seen to be between the same individuals and for the suckler cows, between mother and calf. In the Thuringian Rhoen and South Black Forest, social and individual grooming behavior was only rarely observed within the selected scan sampling methods. Both types of behavior occurred for only very short periods. For all observed groups of cattle, social behavior amounted to under 1% and grooming behavior between 0 and 1%.

Habitat Use

The characteristic effects of cattle on the vegetation are shaped through feeding, encamping, walking to different areas and visiting water sources (Cornelius et al. 1998). This was realized on all of the investigated pastures through particular grazing patterns, established camps, marked routes and areas of open ground near the water sources. In the first investigation year, all of the observed cattle groups kept themselves most frequently to areas of open land (= grazing land without woody vegetation, water sources, paths or encampments) with use proportions between 58% and 89%. These results agree with the accepted knowledge that with regard to digestion physiology, cattle are classified as 'grazers' (Hofmann 1989) and are therefore dependent on open, grassy areas. Most of the research in the professional literature on habitat use concerns semi-wild or wild living animals although similar use preferences are clearly seen in domestic cattle. Semi-wild cattle in The Netherlands were observed 57% on grassland and 17% in woodland areas (Bokdam et al. 2003). Investigations by Putman et al. (1987) showed that for cattle in the New Forest, there were relatively constant habitat use patterns with grassland areas being preferred 70% to 80% for feeding. Woody species on pastures have an important function as protection against weather, as nutritional supplement, for grooming behavior and generally for the well-being of the cattle. The proportional use of woody growth formations during the daylight observations in the Thuringian Rhoen was between 10–48% with an absolute greater frequency of use on the set stocking pastures. The preference indexes for use of woody structures were the reverse of those for open land areas. On the rotational pastures, wooded areas were more preferred than other habitat types and on the set stocking pastures, the use ranged from neutral to a tendency to avoid them. Individual comparisons of set stocking and rotational pastures in the Thuringian Rhoen, however, did not show any significant differences in the use of woody vegetation. The varying weather conditions during the observation days may have played a role. The cattle visit trees for protection against heat and insects, but also for protection against rain showers and wind (see Hancock 1953; Sambraus 1978). The results for woody vegetation use are also similar to those from the literature on habitat use by semi-wild and wild living cattle. Pratt et al. (1986) observed semi-wild cattle in the New Forest at 10–20% in the woodland. In a habitat comparison, the cattle avoided woods and clearances in the New Forest for feeding and preferred grassland (Putman et al. 1987).

Because of the relatively rare visits to water sources, the observed periods there were relatively low (0–4%). From the preference index calculations, water sources on rotational pastures were preferred to those on set stocking pastures in the investigated areas. According to Hancock (1953) and Sambraus (1978), the uptake of water reduces with increasing distance from the water source. The rotational pastures were relatively small and the drinking troughs were therefore located at shorter distances than on the set stocking pastures. On the rotational pasture *RH-RP* and the set stocking pasture *EB*, the drinking troughs were more frequently visited than on all other pastures, and on *RH-RP*, significantly more frequently visited than on the neighboring set stocking pasture *RH*. The most frequent visit periods for cattle from RH-RP and EB to drinking troughs are explained by insufficient water supply on the pastures with slow surface water flows and the long standing periods at the water container. The numbers of cattle were relatively high on both pastures so many animals did not come to drink at all.

In the investigation areas, the paths on the pastures made up between 0.1 and 1.5% of the individual pastures. There were no clear differences between set stocking and rotational pastures. The highest path densities were on the rotational pasture of the South Black Forest (1.5% of the whole area in each case). The reason for this is assumed to be the significantly longer grazing use of the area and the resulting very long development of pasture structures. Considering 100% of all paths on all pastures, the path density on the small rotational pastures was the lowest with 3% and the highest on the very large set stocking pastures with 38%. Narrow paddocks result in considerable trampling effects in confined spaces. On the elongated set stocking pasture *EB* also, there was increased occurrence of open ground caused through trampling. The drinking troughs were located in the narrowest parts of the pasture. The use of existing paths was observed for between 1–8% of the whole habitat use. In a comparison of the pastures, most of the observations of cattle on established paths were found for the set stocking pasture *EB*. This is connected to the high proportion of travel movement compared to the other cattle groups, which on pasture *EB* was almost exclusively on the paths and hardly ever alongside paths or across neighboring areas. This was often observed for the cattle on set stocking pastures *RH* and *HB*, for example, where the cattle walked alongside each other or in a wedge formation. The pasture *EB* had an elongated shape and was relatively narrow in places. The frequent path use could be connected to the high cattle numbers and the shape of the area as arising from the protection of their nutritional basis.

Normally, cattle move to resting and camping places after feeding in order to digest the food (Stuth 1991). At the preferred resting places, the lying and repeated excretion and urination of the cattle causes distinctive 'Laegerfluren', or cattle camps, as well as areas of open ground on which according to Woike and Zimmermann (1997), nitrogen-loving grasses and herbs later become established. Through the particular characteristics of these areas, the camps create a distinct habitat category. On the rotational pastures, specific areas were regularly used as resting places and so fixed camps were established. They were characterized by typical Laegerfluren and/or open ground. The analysis of the use of the established camps indicated a clearly higher use for rotational pastures compared to set stocking pastures in all of the statistical calculations. For the small and medium sized rotational pastures, the observations showed proportions of 18% and 20% use, and for the large and very large set stocking pastures, only 3% and 4%. The preference index related to habitat indicated a gradual progression from the preference of camps on small rotational pastures up to an avoidance of camps on very large set stocking pastures in comparison to the other habitats. On both of the rotational pastures of the Thuringian Rhoen (*RH-RP*, *EB-RP*), established camps were significantly more frequently used than on the adjoining set stocking pastures (*RH*, *EB*). On large pastures, cattle have the possibility of frequently changing their feeding and resting areas. Roath and Krueger (1982) report that after walking to drinking troughs and using these, a resting place is sought nearby. This can be confirmed in part by our own observations. However, the cattle often moved to the drinking troughs only after the resting period.

Vegetation Use

The selection of nutrition by cattle is oriented to quality and taste, but also to the effort required to find it and its availability (Distel et al. 1995). Over a certain time, cattle develop experience and memory with respect to potential nutritional habitats which they use to maximize feeding by repeatedly visiting good feeding places (Bailey et al. 1996; Elsäßer 2000). Van den Bos and Bakker (1990) prove a relationship between feeding intensity and the used terrain, that is, between frequency of grazing and the number of visits. The visits recorded in this investigation, which include all behavior types, show that there is a clear preference for nitrophilic grasslands, as in the case of grazing. Rich and poor grasslands and wet lands are preferred to other vegetation areas. A connection between duration of grazing and the length of stay can be found. There were not many wet areas. Occasionally, they were visited mainly for drinking because of a lack of drinking water (pasture *EB*) or sometimes for feeding (pasture *HB*). Hart et al. (1991) found that cattle are more likely to use wet areas at higher levels of stocking. For the relatively highly stocked pasture *EB*, this was the case. The visits to areas of open ground also gave positive preference indexes. Such areas were mainly the paths. They were also present at the drinking places and in part at established camps. The relatively high proportion of movement and in part, the long periods of standing at drinking places are the main determining factors for this.

The frequency of grazing is reflected in the pattern of grazing (Arnold and Dudzinski 1978). The spatial and temporal heterogeneity of the pastures is according to McNaughton and Georgiadis (1986) caused by the cattle maintaining the diversity in the plant competition hierarchy. The large scale of the rotational pastures in the Thuringian Rhoen makes a high variability in the spatial-temporal use of the area by the cattle possible, in contrast to smaller areas (Bontjer and Plachter 2004), which to a large extent was determined by the differentiated spatial-temporal behavior of the cattle. Grumblat (1987), Distel et al. (1995) and Bontjer and Plachter (2002) also associate large scale grazing with the creation of a parceled mosaic structure, arising from a rich nutritional availability from short or long grass areas, sections of woody vegetation and areas of open ground. According to investigations by Itjeshorst and Glader (1994), species which are dependent on short grass profit from such grazing patterns, as do species which would be damaged by frequent browsing, trampling or mowing. Cattle do not take over the whole area in one go, they form concentrated grazing places or several such places spread over the area, which is reflected in a heterogeneous vegetation pattern (Sala 1988; Distel et al. 1995) or in specific spatial-temporal patterns (Bontjer and Plachter 2004). This then has an effect on the food availability and therefore on the behavior of the cattle. In a close mutual relationship between the pasture as nutritional basis and the cattle, the cattle have a decisive co-determining effect on the quality of the nutrition (Pott and Hüppe 1994). Therefore, between cattle and vegetation, there are certain feedback mechanisms (Cornelius et al. 1998).

Locomotion Behavior

According to investigations by Fischer et al. (1998), cattle cover larger distances with increasing pasture sizes. Fraser and Broom (1990) measured daily distances of 2–8 km. In the Thuringian Rhoen, the distance calculations for cattle per day and season were greater on average for the set stocking pastures than the rotational pastures. The pasture sizes correlated positively with the distances covered. The average lowest distance was measured on the rotational pasture *EB-RP* with 1.8 km and the average furthest distance was for the set stocking pasture *EB* with 3.3 km, over the whole of the observation period. In a comparison of the set stocking pastures, it was found the heifers of the breed SMR had a higher level of mobility than the suckler cows and bullocks of the Fleckvieh breed. In a comparison of grazing procedures, it was found that the heifers on the pasture *EB* were significantly more mobile than on pasture *LA*. According to Arnold and Dudzinski (1978), young cattle generally cover greater distances than suckler cows with calves.

This may also be determined by breed in the Thuringian Rhoen. Herbel and Nelson (1966) and Sneva (1970) found differences between the cattle breeds. Schalitz and Beckmann (1998) found that SMR with 3.5 km d^{-1} were somewhat more mobile than Galloways with 3.0 km d^{-1} on the same size of pasture. Investigations by Funston et al. (1991) on different Hereford cattle, however, found no differences between the breeds for the averaged distances covered on equal pasture sizes, amounting to 2.8 km, 3.1 km, 3.4 km and 4.0 km d^{-1}. Investigations of relationships between distance and the age of the cattle were carried out by Dunn et al. (1988). Three-year cows with 5.6 km d^{-1} covered further distances than five-year-olds with 4.8 km d^{-1} and seven-year-olds with 4.7 km d^{-1}. Johnstone-Wallace and Kennedy (1944) undertook locomotion studies on rotational pastures of 0.5 to 3 ha size and measured daily distances of 2.2 km. Morgan (1951) measured distances of 2.6 km d^{-1} on rotational pastures of 3.5 to 5.5 ha. Hancock (1950) determined distances of 2.8 km on 1 ha of pasture. Peterson and Woolfolk (1955) established distances of 3.2 km d^{-1} on a 41 ha pasture. They too found increasing distances with increasing pasture sizes. While cows in small paddocks cover distances of 2.7 km d^{-1}, this increased to 9 km in larger paddocks. Shepperd (1921) also found increases in distances related to increases in pasture sizes. On 12 ha, distances of 2.7 km were measured, on 41 ha, 5.0 km and on 260 ha, 8.9 km d^{-1}. Herbel and Nelson (1966) determined distances of 6.9 km d^{-1} for Santa Getrudis cows and 14.6 km d^{-1} for Hereford cows in semi-wild situations on 1 000 to 1 500 ha. On large-scale pastures in the Camargue, cattle covered three times the distance compared to small rotational pastures (Zeeb 1983). Calculations by Walker et al. (1985) produced a greater variance in the daily distances covered on rotational pastures compared to set stocking pastures. According to Walker et al. (1985), this is a result of the combination of high stocking density, the proximity between the herds and social interactions.

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6.2

Mesoscale Vegetation Structure on Differently Used Cattle Pastures in the Thuringian Rhoen

Andrea Bontjer

6.2.1

Introduction

Where livestock have a large area of grazing land available, they adapt their behavior and their choice of nutrition to this situation and the grazing pressure results in a differentiated spatial-temporal pattern. At the mesoscale, this increased stochasticity of the livestock effects can be shown using area surveys of the vegetation structure.

The objective of the investigation presented here was to document the development of the vegetation structure, the proportion of unused grazing and the availability of resources on large-scale set stocking pastures with different uses, and to compare these with regular rotational pastures.

6.2.2

Approach

Until now, related investigations with ordinary livestock had not been possible because of a lack of suitable investigation sets. There was also no suitable method of surveying which would give a satisfactory compromise between local degrees of differentiation, area coverage and repetition frequency. An experimental reintroduction of large-scale set stocking pasturing for cattle in the Thuringian Rhoen offered the opportunity of setting up pastures for different uses and of subjecting these to a comparative investigation. Great value was placed on the comparison of large-scale set stocking pastures with smaller rotational pastures. All investigations were based on the normal work routines of a farming enterprise.

Four set stocking pastures of between 20 and 35 ha and two smaller rotational pastures in the Thuringian Rhoen were analyzed (see Sect. 3.1). The set stocking pastures were continuously grazed from May to September/October and the rotational pastures were stocked three times for several days, as is normal. The set stocking pasture at Lichtenau could be enlarged from 35 ha to 50 ha in the second year (2002). At the same time, the stocking density was reduced from 2 to 1 LSU ha^{-1}, because the density in the first year turned out to be too high, so in the meantime, the animals had to be removed from the pasture. The set stocking pasture was mowed at the end of the grazing period in the first year of investigation (2001).

With respect to the investigations of the development of vegetation in the area, it had to be borne in mind that long-term effects could not be analyzed within the duration of the project. Therefore, parameters had to be selected that would react quickly to a change in use, with changes which were measurable in the short-term and which could be clearly referenced to the activities of the grazing animals.

The primary considerations in this regard were about the data on vegetation structure and the availability of resources such as flowering vegetation. Of course, these parameters are also affected by other factors such as the composition of species, the soil conditions and the previous land use. The *vegetation height* is dependent on the grazing activity of the cattle, as well as factors such as species composition and soil conditions. In particular, changes to the height in the course of the grazing period allow conclusions to be drawn about the intensity of grazing. Because the data on vegetation height do not always give consideration to the exact spatial structure alone, the parameter *grazing structure* was introduced which represents the vegetation structure resulting from the effects of grazing.

The availability of flowering vegetation is an important resource for invertebrates and is naturally lacking in Central European landscapes in high summer as well as after mowing the pastures. The question is therefore interesting as to whether large-scale pastures provide a continuous supply.

A consequence of undergrazing is that grazing residues remain which from an agricultural point of view are undesirable. However, these are interesting from an ecological viewpoint as a habitat or nutritional resource for wild animals.

Even so, undergrazing should not lead to the appearance of large areas of encroachment. In order to consider the proportion of herbaceous vegetation not grazed short by the end of the grazing period, the parameter *grazing residue* was introduced.

With respect to the starting hypothesis, the following sub-hypotheses were processed in this investigation:

- A spatial-temporal heterogeneity of the livestock effect is verifiable on large-scale set stocking pastures.
- Large-scale set stocking pastures offer a more continuous supply of flowers than rotational pastures.
- To a similar extent as on rotational pastures, the vegetation growth on large-scale pastures is as completely utilized – with a corresponding stocking density – by the end of the grazing period.

6.2.3
Methodology

The priority objective was to create an area-wide picture of the vegetation structure as it changed during the course of the grazing period. For this purpose, it was necessary to apply surveying methods at the mesoscale level that would mean sacrificing a degree of detail. It was therefore necessary to assign the vegetation to relatively rough categories. In the process, the parameters grazing structure, vegetation height, grazing residue, and flower occurrence were surveyed over the whole area (Table 6.12). All parameters refer to the herbaceous-grassy vegetation. For a detailed description of the methods and an explanation of the classes, see Sect. 4.2.

For all areas, the mapping of the parameters for vegetation height and grazing structure was surveyed in 2001 and 2002. The parameter for flower availability was surveyed in 2002, three to five times for each pasture. The parameter for grazing residue was surveyed once for each pasture at the end of the grazing period (Table 6.13).

The area of Lichtenau could not be mapped in 2001 in August and the grazing residue assessment could not be carried out because the pasture had already been mowed

Table 6.12.
Mapped structural parameters

Parameter	Classes
Vegetation height	Free of vegetation, <10 cm, 10–20 cm, 20–30 cm, >30 cm
Grazing structure	Free of vegetation, short, short with tufts, small areas patchy, large areas patchy, superficial, nothing grazed
Grazing residues	None, little, medium, many
Flower availability	None, little, medium, many

Table 6.13. Survey dates for the parameters

	Rotenhauck set stocking	Rotenhauck rotation	Ellenbogen set stocking	Ellenbogen rotation	Hemschenberg set stocking	Lichtenau rotation
2001						
Vegetation height Grazing structure	25 May 10 July 16 August 26 Sept.	25 May 18 June 01 August 26 Sept.	16 June 26 July 27 Sept.	27 June 27 July 25 Sept.	30 May 03 July 13 August 24 Sept.	06 June 04 July
Grazing residue	26 Sept.	26 Sept.	27 Sept.	25 Sept.	24 Sept.	
2002						
Vegetation height Flower availability Grazing structure (not in May)	02 May 12 June 16 July 12 August 24 Sept.	02 May 12 June 16 July 12 August 24 Sept.	10 May 21 June 23 July 13 August 25 Sept.	08 May 11 June 12 August 26 Sept	03 May 14 June 14 July 13 August 30 Sept.	05 May 13 June 18 July 14 August 20 Sept.
Grazing residue	24 Sept.	24 Sept.	25 Sept.	26 Sept.	30 Sept.	20 Sept.

before the planned mapping exercise. Also, the mapping of the rotational pasture at Ellenbogen was omitted in July 2002 for organizational reasons.

6.2.4
Results

Vegetation Height and Grazing Structure

For the whole of the grazing period, the set stocking pasture showed a heterogeneous pattern of sub-areas which had been grazed to different extents. Extending into July, there were large areas with a vegetation height of over 30 cm, while neighboring areas were already grazed short (Fig. 6.9). For the Rotenhauck area in July 2001, a quarter of the area was still over 30 cm high and almost 35% was under 10 cm (Table 6.14). In August, 30% of the area was still 20–30 cm high and 40% was already under 10 cm. At the end of the grazing period, however, over 80% was grazed short and only 3% of the area was over 20 cm.

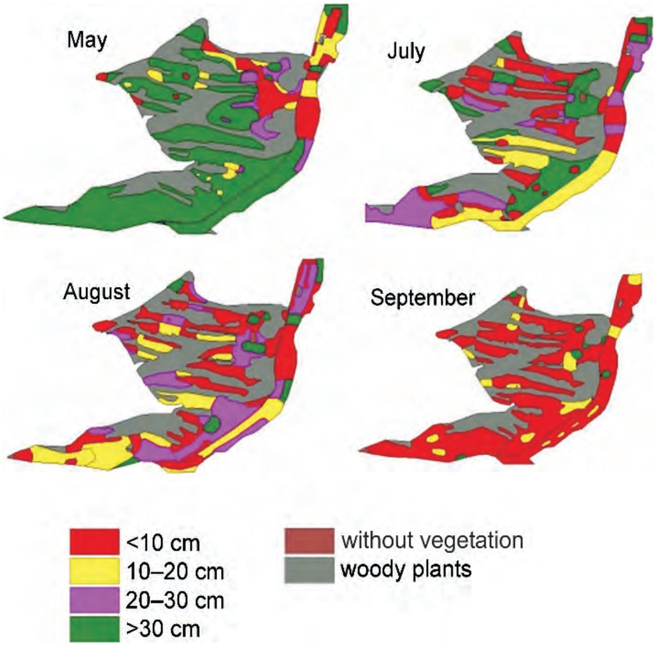

Fig. 6.9.
Spatial distribution of vegetation height on the set stocking pasture Rotenhauck during the course of 2001

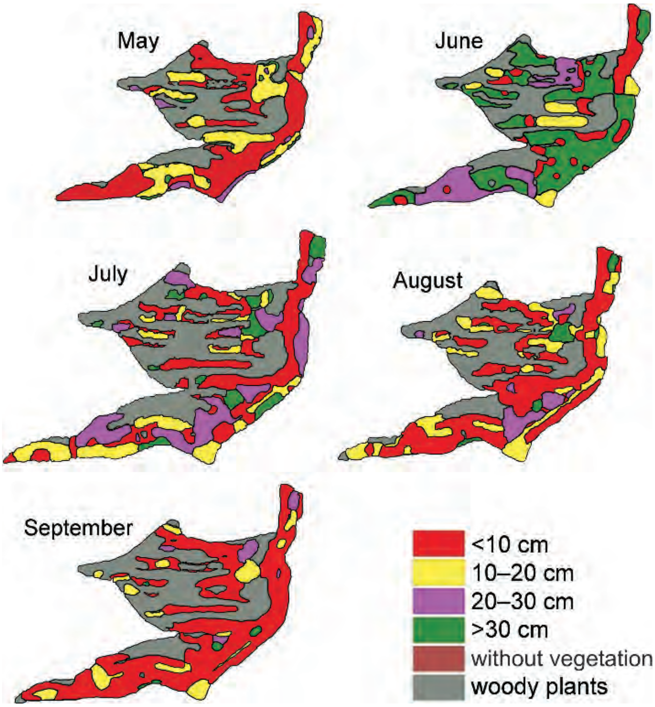

Fig. 6.10.
Spatial distribution of vegetation height on the set stocking pasture Rotenhauck during the course of 2002

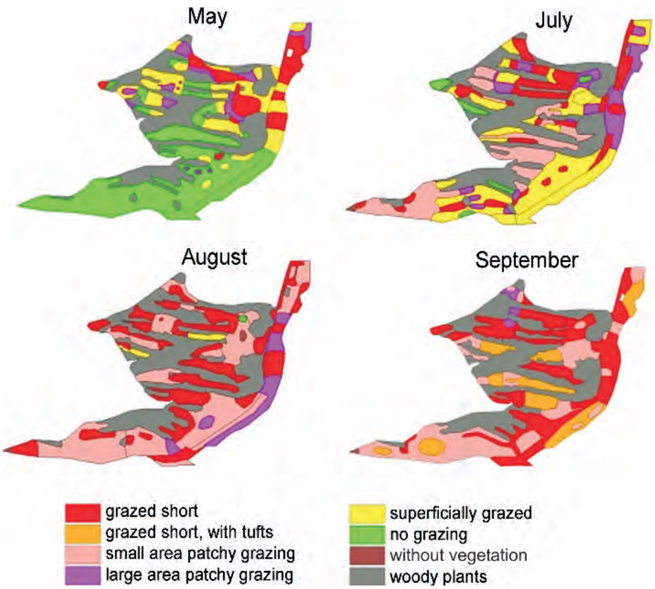

Fig. 6.11. Categories 'grazing structure' on the set stocking pasture Rotenhauck, 2001

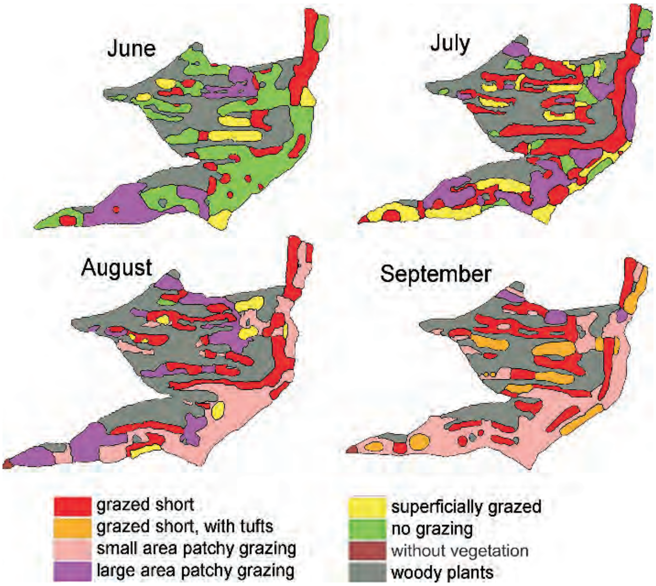

Fig. 6.12. Categories 'grazing structure' on the set stocking pasture Rotenhauck, 2002

For 2002 (Table 6.15), the set stocking pasture Rotenhauck gives a similar picture of the distribution of height classes as in 2001, although the values deviate in certain aspects because of the spatial-temporal variance of the grazing pressure and different weather conditions affecting growth (Fig. 6.10). Again, there is a mosaic of higher and lower vegetation during the summer and a higher proportion (76%) for short vegetation at the end of grazing period. The high proportion of low vegetation in May 2002 is a

Table 6.14. Area proportions (in %) for vegetation height 2001 (averages rounded)

Rotenhauck St

	5–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	13	8	6	72	0
July	34	19	22	25	0.4
Aug.	40	25	30	5	0.5
Sept.	86	10	0	3	0.5

Rotenhauck U

	5–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	0	0	40	60	0
June	11	57	13	17	0.4
Aug.	53	15	26	6	0.8
Sept.	87	10	0	0	3

Ellenbogen St

	5–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
June	9	9	37	44	2
July	33	23	37	7	2
Sept.	80	9	9	0.1	2

Ellenbogen U

	5–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
June	25	14	27	30	4
July	68	3	20	5	3
Sept.	80	13	0	4	4

Hemschenberg St

	5–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	3	26	35	36	0
July	8	3	30	59	0.3
Aug.	31	7	42	21	0.1
Sept.	44	16	37	4	0.1

Lichtenau St

	5–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
June	18	25	42	15	0.4
July	65	15	13	5	1

Table 6.15. Area proportions (in %) for vegetation height 2002 (values rounded. *n.d.*: no data)

Rotenhauck St

	0–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	60	32	7	0	1
June	20	8	18	54	1
July	45	18	26	11	1
Aug.	52	30	10	8	1
Sept.	76	17	5	2	0.4

Rotenhauck U

	0–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	44	56	0	0	0
June	63	31	4	2	0
July	67	31	1	1	0
Aug.	85	15	0	1	0
Sept.	62	36	0	1	0

Ellenbogen St

	0–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	71	24.64	4	0	0
June	22	26	27	23	2
July	41	36	20	3	1
Aug.	66	22	8	3	1
Sept.	81	14	2	1	1

Ellenbogen U

	0–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	19	7	7	1	0
June	40	44	7	7	2
July	n.d.	n.d.	n.d.	n.d.	n.d.
Aug.	78	7	7	6	2
Sept.	78	13	1	6	2

Hemschenberg St

	0–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	63	37	0	0	0
June	12	26	28	35	0
July	19	35	40	7	0
Aug.	46	34	13	6	0
Sept.	70	25	2	3	0

Lichtenau St

	0–10 cm	10–20 cm	20–30 cm	>30 cm	veg. free
May	45	44	9	3	0
June	33	1	16	48	1
July	50	6	37	7	1
Aug.	62	20	13	4	1
Sept.	73	21	2	4	0.2

result of the mapping being carried out at the beginning of May and at this time, the vegetation had not grown very much.

Similar proportions to the results for the set stocking pasture Rotenhauck are found for the set stocking pasture Ellenbogen. A comparison of both pastures shows that the area proportions for height class in the individual months largely agree.

On the set stocking pasture Lichtenau, the vegetation in July 2001 had already been so much utilized (65% under 10 cm) that the cattle had to be rotated to another pasture. It was only after a few weeks that they could be returned to the original pasture. The stocking density was, therefore, too high for this pasture. For this reason, the stocking density for the second year of the investigation was lowered from 2 to 1 LSU ha^{-1}. After this, the animals could spend the whole grazing period on the pasture and the vegetation structure developed in the way described for the set stocking pastures Rotenhauck and Ellenbogen.

Unlike for the Lichtenau area, the vegetation growth on the set stocking pasture Hemschenberg was insufficiently utilized during the first year. In September, only 44% of the area was grazed to under 10 cm and 37% was 20–30 cm high. This is less a result of the stocking density (0.8 LSU ha^{-1}) but of the fact that a neighboring meadow was joined to the pasture after the July mowing and the cattle preferred the fresh growth available there. This was not repeated in the second year of the investigation, and again, similar structure data was found as on the other set stocking pastures.

The results of the grazing structure showed that the cattle use some areas of the large pastures very late (from June/July) so these areas remain largely undisturbed (Fig. 6.11 and 6.12, Table 6.14 and 6.15). Except for the set stocking pasture Ellenbogen which had the highest stocking density of all the set stocking pastures, in June 2002 12% (Rotenhauck), 16% (Lichtenau) and 17% (Hemschenberg) were still not grazed. After July, all areas had been grazed.

The highest area proportions for 'grazing structure' were for the categories 'small areas patchy' and 'large areas patchy'. This means that the selectivity for grazing particular areas was high, allowing neighboring areas of vegetation of different heights to arise. The category 'small areas patchy' took up the highest proportion at the end of the grazing period. In addition, areas grazed to the same low height were increasingly found. At the end of the grazing period 2002, 10% (Hemschenberg), 15% (Lichtenau) and almost 30% (Rotenhauck, Ellenbogen) of the areas of the set stocking pastures were grazed short and with the exception of Rotenhauck, the areas with the highest stocking density had the highest proportion of short-grazed vegetation.

The proportions of the grazing structure classes (Table 6.16 and 6.17) of the set stocking pasture Rotenhauck (Fig. 6.13) agree surprisingly closely with those of the set stocking pasture Ellenbogen (Fig. 6.14), although the stocking densities were different (0.8 LSU ha^{-1} and 1.8 LSU ha^{-1} respectively). This can be explained by the fact that the area Rotenhauck is very rich in woody vegetation (about 30% cover) and therefore the actual stocking density on the herbaceous-grassy vegetation is in practical terms clearly higher than 0.8 LSU ha^{-1}.

During the summer, the rotational pastures provided a lower structural variety than the set stocking pastures because after the first rotation in June, a large part of the vegetation had been grazed to under 10 cm (60% on the set stocking pasture Rotenhauck in 2002) (Fig. 6.15; Table 6.14 and 6.15). The classes>20 cm made up only a small proportion.

Fig. 6.13.
Proportions for the classes for grazing structure in area %, set stocking pasture Rotenhauck, 2001 and 2002

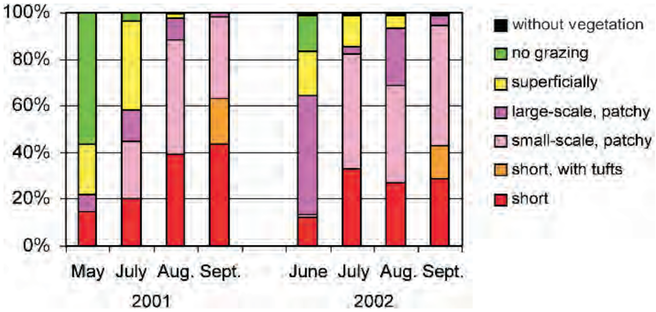

Fig. 6.14.
Proportions for the classes for grazing structure in area %, set stocking pasture Ellenbogen, 2001 and 2002

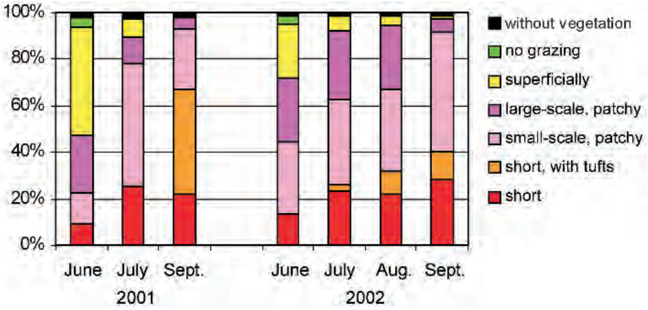

Fig. 6.15.
Vegetation heights for the rotational pasture Rotenhauck, 2002

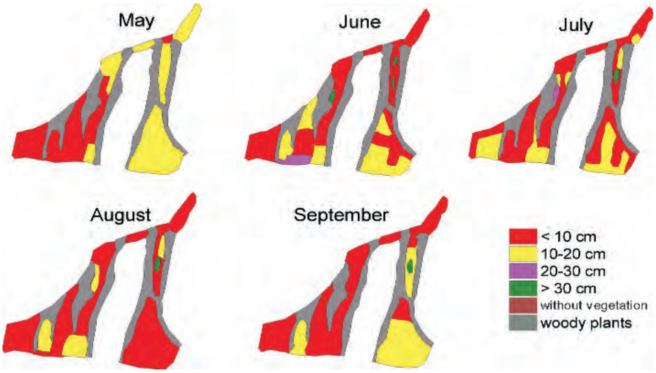

Fig. 6.16.
Classes for grazing structure, rotational pasture Rotenhauck, 2002

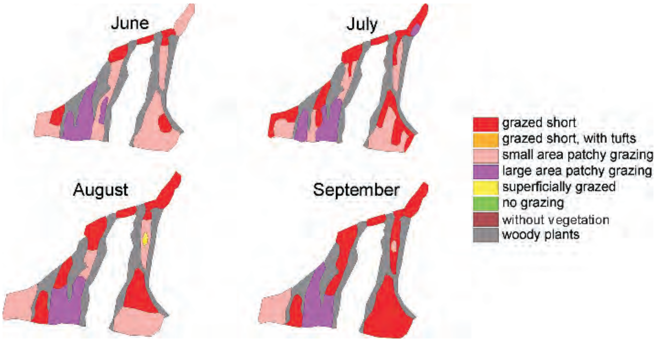

Table 6.16. Area proportions (in %) for the classes for grazing structure 2001 (values rounded)

Rotenhauck St

	1	2	3	4	5	6	7
May	15	0	0	8	21	56	0
July	20	0	24	13	38	3	0
Aug.	39	0	48	9	2	0	0
Sept.	44	19	35	2	0	0	0

Rotenhauck U

	1	2	3	4	5	6	7
May	0	0	0	0	0	100	0
July	15	0	49	2	33	0	2
Aug.	31	0	55	5	7	0	2
Sept.	28	44	14	12	0	0	3

Ellenbogen St

	1	2	3	4	5	6	7
June	9	0	13	24	46	5	2
July	25	0	52	11	8	0	3
Sept.	22	44	26	5	0	0	2

Ellenbogen U

	1	2	3	4	5	6	7
June	12	0	48	0	29	8	3
July	23	0	66	0	7	0	4
Sept.	62	0	35	0	0	0	4

Hemschenberg St

	1	2	3	4	5	6	7
May	7	0	0	31	29	33	0
July	9	0	5	35	49	2	0
Aug.	15	0	37	34	14	0	0
Sept.	25	17	43	14	0	0	0

Lichtenau St

	1	2	3	4	5	6	7
June	7	0	10	47	29	5	0
July	10	56	5	1	17	11	1

Table 6.17. Area proportions (in %) for the classes for grazing structure 2002 (values rounded)

Rotenhauck St

	1	2	3	4	5	6	7
June	12	0	1	51	19	16	1
July	33	0	49	3	14	0	1
Aug.	27	0	42	25	6	0	1
Sept.	29	14	51	4	1	0	0

Rotenhauck U

	1	2	3	4	5	6	7
June	17	0	61	23	0	0	0
July	42	0	37	20	0	0	0
Aug.	41	0	40	18	1	0	0
Sept.	65	0	14	20	0	0	0

Ellenbogen St

	1	2	3	4	5	6	7
June	14	0	30	28	23	3	2
July	23	3	37	30	6	1	1
Aug.	22	10	35	28	4	0	1
Sept.	28	12	52	6	1	0	1

Ellenbogen U

	1	2	3	4	5	6	7
June	20	0	59	0	14	6	1
July	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d
Aug.	28	0	53	12	12	2	1
Sept.	14	21	57	0	4	3	2

Hemschenberg St

	1	2	3	4	5	6	7
June	7	0	5	47	24	17	0
July	11	0	32	37	17	3	0
Aug.	15	0	29	43	10	3	0
Sept.	9	11	75	0	4	0	0

Lichtenau St

	1	2	3	4	5	6	7
June	10	21	17	28	11	12	1
July	16	26	42	6	9	0	1
Aug.	8	55	26	2	8	0	1
Sept.	15	54	27	0	3	0	0

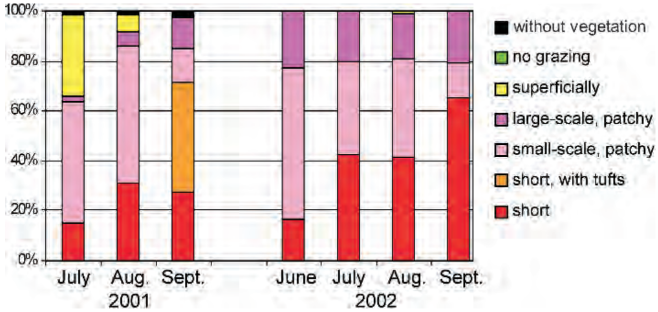

Fig. 6.17.
Shares of classes for grazing structure in area %, rotational pasture Rotenhauck, 2001 and 2002

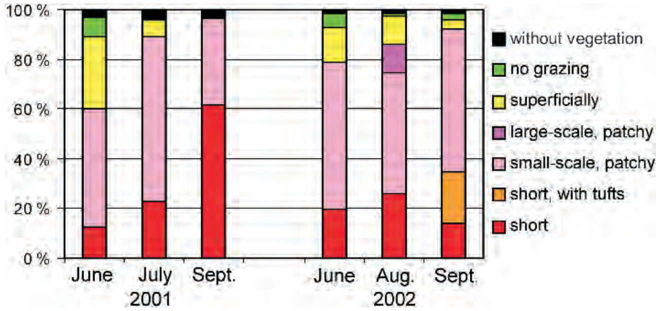

Fig. 6.18.
Shares of classes for grazing structure in area %, rotational pasture Ellenbogen, 2001 and 2002

In a comparison to the neighboring set stocking pastures, it is clear that the proportions for height classes in September are almost identical. The set stocking form of use therefore is no disadvantage with respect to the utilization of vegetation growth.

On the rotational pasture Rotenhauck, all areas had already been grazed after the first rotation in June in both years (Figs. 6.16–6.18). There were no undisturbed areas. On the rotational pasture Ellenbogen, there were only areas of stinging nettle growth and edges of woody vegetation that had not been grazed.

The rotational pastures also had high proportions for the classes 'small areas patchy' and 'large areas patchy'. The proportion of short grazed vegetation varied in the two years of the investigation. The rotational pasture Rotenhauck had figures of 28% in 2001 and 65% in 2002. The rotational pasture Ellenbogen was the other way round with 65% in 2001 and 14% in 2002. The remaining proportions were for the classes 'short with tufts' and 'patchy'.

Flower Availability

The availability of flowers on the set stocking pastures was high during the whole 2002 grazing period (Table 6.18). Areas which were free from or low in flowers took up only small proportions. The set stocking pastures Hemschenberg and Lichtenau both had a high availability during the whole summer. The development of the flower availability (classes medium and large on the area at Hemschenberg ranged from 13% (May) to almost 90% (June), over 90% (July), almost 80% (August) and almost 25% (September). In high summer (July and August), the proportion for the category 'many flowers' was almost 30% (Fig. 6.19 and 6.20, Table 6.18). Areas without flowers first appear in

Table 6.18. Proportions (in %) of the class 'flower availability' 2002 (*n.d.:* no data. *ss:* set stocking, *rg:* rotational grazing)

May	None	Few	Medium	Many
Rotenhauck ss	0	24	76	0
Rotenhauck rg	0	28	71	3
Ellenbogen ss	3	51	43	4
Ellenbogen rg	30	53	12	4
Hemschenberg	0	84	13	1
Lichtenau ss	2	82	7	9

June	None	Few	Medium	Many
Rotenhauck ss	0	22	44	34
Rotenhauck rg	20	52	29	0
Ellenbogen ss	2	51	42	6
Ellenbogen rg	3	66	25	6
Hemschenberg	0	13	82	6
Lichtenau St	6	70	23	1

Juli	None	Few	Medium	Many
Rotenhauck ss	0	19	56	25
Rotenhauck rg	18	57	22	3
Ellenbogen ss	2	15	74	8
Ellenbogen rg	n.d.	n.d.	n.d.	n.d.
Hemschenberg	0	5	67	27
Lichtenau ss	24	49	26	2

August	None	Few	Medium	Many
Rotenhauck ss	4	20	47	28
Rotenhauck rg	31	62	8	0
Ellenbogen ss	3	23	55	19
Ellenbogen rg	5	60	34	0
Hemschenberg	3	16	50	29
Lichtenau ss	1	20	64	14

September	None	Few	Medium	Many
Rotenhauck ss	14	34	52	0
Rotenhauck rg	9	16	0	75
Ellenbogen ss	26	63	11	0
Ellenbogen rg	72	28	0	0
Hemschenberg	4	73	24	0
Lichtenau ss	27	34	35	4

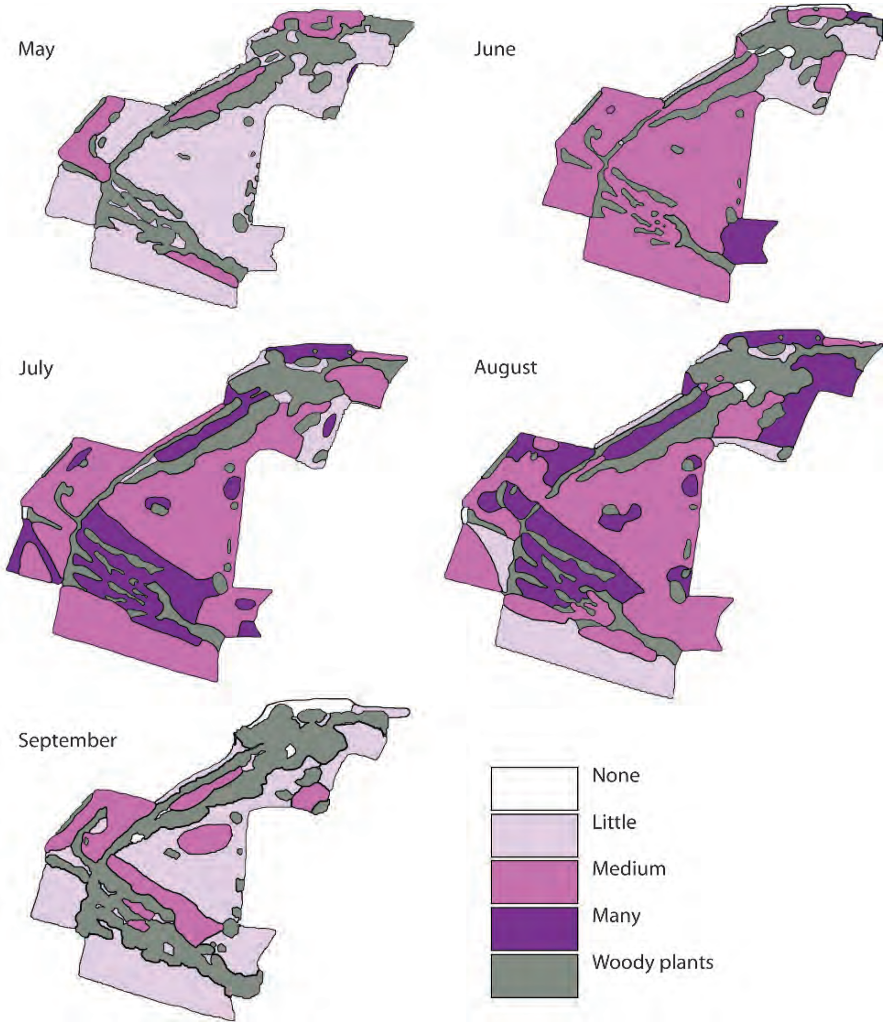

Fig. 6.19. Classes of 'flower availability', set stocking pasture Hemschenberg, 2002

August and are extremely low, with 3% (August) and 4% (September). It was noticeable that on some areas with medium to high numbers of flowers, the proportion could actually increase during the course of the summer and so compensate for areas with low availability arising from the mowing of adjacent meadows. Using the example of set stocking at Lichtenau, the proportions amounted to 16% in May, 24% in June, 28% in July, 78% in August and 39% still in September.

Compared to the rotational pastures, the set stocking pastures provide a continuous availability of flowering plants. While the availability in May is equal on both set stocking and rotational pastures, another picture arises in June. While the proportion for

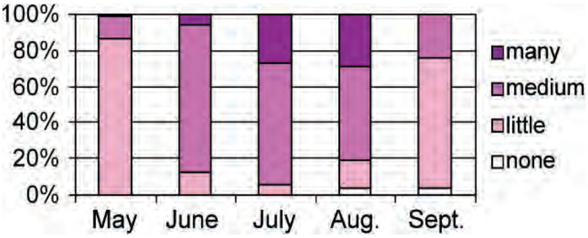

Fig. 6.20.
Shares of categories for flower availability in area %, set stocking pasture Hemschenberg, 2002

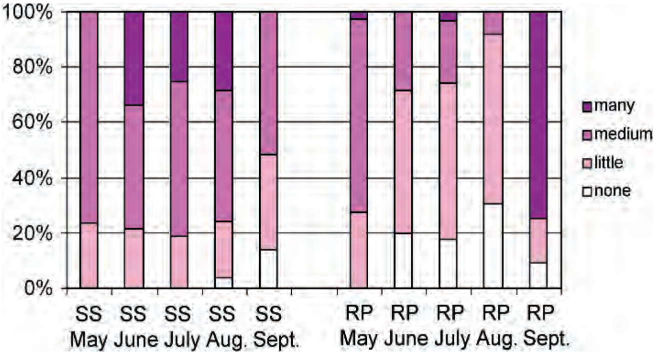

Fig. 6.21.
Shares of categories for flower availability in area %, set stocking pasture and rotational pasture Rotenhauck, 2002

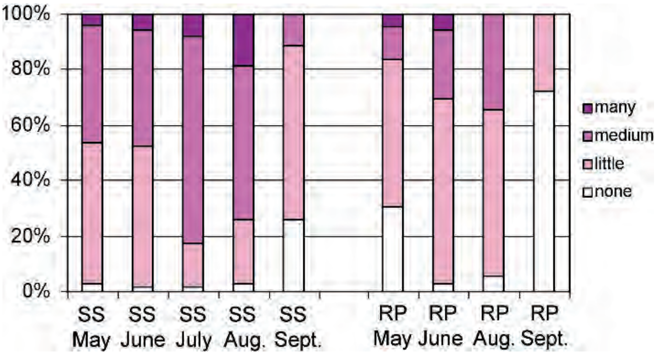

Fig. 6.22.
Shares of categories for flower availability in area %, set stocking pasture and rotational pasture Ellenbogen, 2002

categories medium to many flowers on the set stocking pasture Rotenhauck was almost 80%, the figure for the rotational pasture was only nearly 30% (Fig. 6.21). Also, the Ellenbogen areas showed differences, if not so great (set stocking 47%, rotational about 30%) (Fig. 6.22). In August, the situation was even more extreme: while the set stocking pasture Rotenhauck was still showing figures of 75% for medium or many flowers, only 7.5% was found for the rotational pastures. There is, therefore a situation of real shortage with respect to this resource in high summer on the rotational pastures. The high values for the class 'many flowers' in September (75%) for the set stocking pasture Rotenhauck was a result of the sowing of this area with red clover which had flowered shortly before the survey. Other flowers were not present.

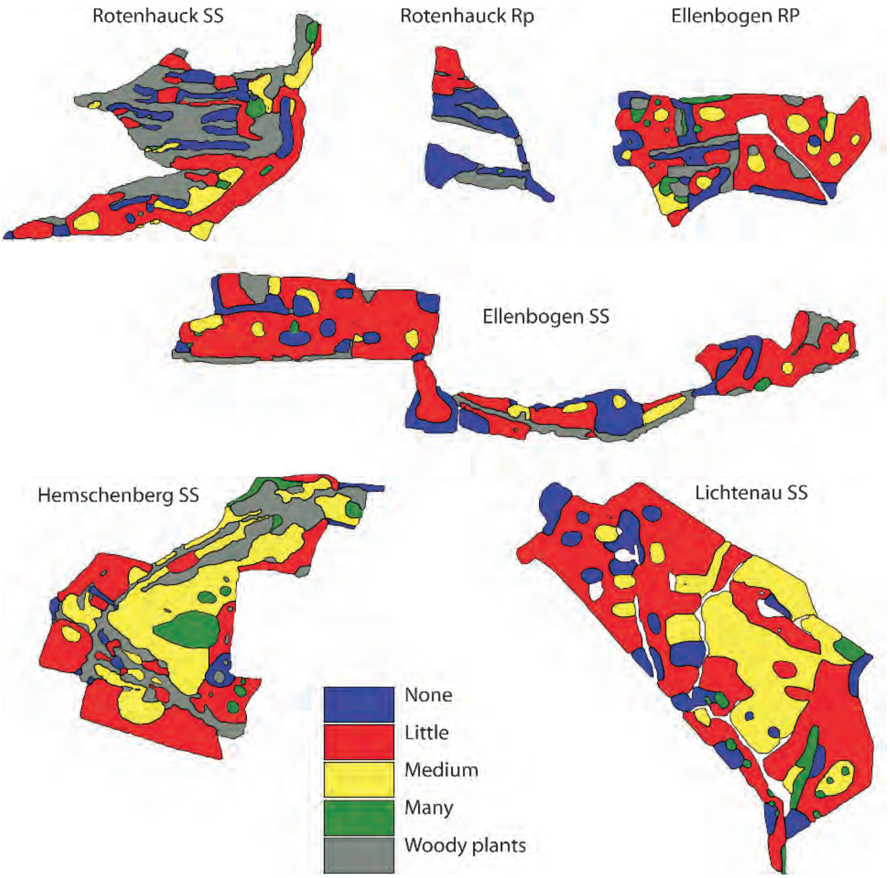

Fig. 6.23. Grazing residues on all areas at the end of the grazing period 2002

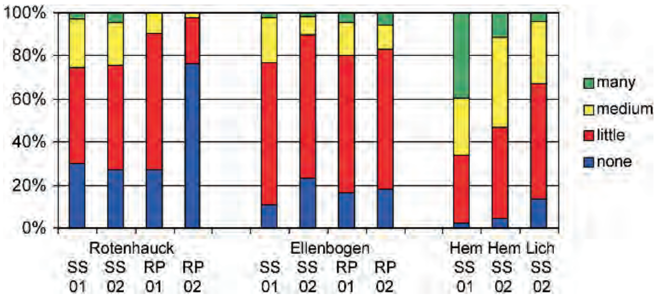

Fig. 6.24. Shares for the class grazing residues in area % for all areas in 2001 and 2002 at the end of the grazing period

Grazing Residues at the End of the Grazing Period

The proportion of undesirable (from the farmer's point of view) grazing residues (unused biomass: 'tangle') at the end of the grazing period on some set stocking pastures

Table 6.19. Shares (in %) for the class grazing residues in 2001 and 2002 (*n.d.:* no data) (values rounded) at the end of the grazing period; *ss:* set stocking, *rp:* rotational pastures

	Grazing residue 2001				Grazing residues 2002			
	None	Few	Medium	Many	None	Few	Medium	many
Rotenhauck ss	30	45	23	3	27	49	20	5
Rotenhauck rp	27	63	10	0	76	22	2	0
Ellenbogen ss	11	66	21	2	23	67	8	2
Ellenbogen rp	16	64	15	4	18	65	11	5
Hemschenberg ss	2	32	26	39	4	43	42	11
Lichtenau ss	n.d.	n.d.	n.d.	n.d.	14	53	29	4

is as expected, higher than on the rotational pastures (Fig. 6.23 and 6.24, Table 6.19). However, on both areas at Ellenbogen, the proportions were comparable and in 2002, there is even less residue present than on the rotational pasture. The set stocking pasture Ellenbogen was relatively highly stocked with a density of 1.8 LSU ha^{-1}. That means that this stocking level is comparable with the level on the rotational pasture (6 LSU ha^{-1}, 3 × 5–10 days) with respect to the utilization of the vegetation.

On the set stocking pasture Rotenhauck, the utilization of vegetation growth is very satisfactory. For both years of the investigation, about 75% of the areas were affected with no and few grazing residues.

In 2001, there was a very high proportion of grazing residues on the Hemschenberg area. The reason for this finding is that an adjacent meadow was mowed on July 1, 2001 and then opened to the grazing land. The cattle grazed from this freshly growing supply of grass in preference to the original area leaving the latter to grow to seed. In the second year of the investigation this was omitted, resulting in a better utilization of the existing vegetation and a reduction in the level of grazing residue.

The utilization of the vegetation is therefore not just dependent on the size of the pasture. The stocking density also has a significant impact. Even for large areas of pasture, then, the farmer can achieve satisfactory results by applying an appropriate system of grazing management, as shown in the case of the set stocking pasture Rotenhauck. From the point of view of nature conservation, a situation such as that in the Hemschenberg area in 2002 is desirable. There, grazing residues were present but the vegetation had been grazed to the extent that over the long term, no encroachment could result.

6.2.5
Discussion

The investigations have shown that the grazing activity of the cattle on large set stocking pastures result in a spatial-temporal heterogeneous pattern of grazing with long-undisturbed areas, while for rotational pastures, the areas were already relatively equally grazed after the first rotation. At the end of the grazing period, both forms of use on the areas Rotenhauck and Ellenbogen were comparable with regard to vegetation height.

However, it should be noted here that the grazing period had been extended by a few weeks into autumn for experimental reasons and it was in this phase that the comparisons of the two variants were made. The livestock gains in weight, however, did not vary significantly between the two variants.

For the comparison of the different grazing systems – set stocking and rotational grazing – it should be noted that the rotational pastures are significantly smaller than the set stocking pastures and form only a part of a grazing system in which other rotational pastures are used, which were, however, not investigated. In order to guarantee the comparability of both systems of use, only the rotational pastures which were immediately adjacent to both of the set stocking pastures were investigated. The other rotational pastures were located further away and were not suitable for the investigation because of the different local conditions.

Of course, rotational pastures also offer certain specific resources because they are used at different time intervals compared to set stocking systems. Areas of land in a rotational grazing system remain ungrazed for longer at the start of the grazing period and therefore offer undisturbed areas of grassland. The following impacts on the grazed areas are then very great, however, so that resources such as flowers and higher-growing vegetation are largely absent after the first grazing, as was shown by the investigations on the rotational pastures.

An important factor in the establishment of grazing systems is the selection of stocking density. As this investigation has shown, the spatial-temporal utilization of the pasture is also dependent on the number of animals on each area. For this reason, the subject of stocking densities for different grazing systems is discussed in the literature of both nature conservation and agriculture (for example, Nitsche and Nitsche 1994; Oppermann and Luick 1999). There are various factors to consider here. Of importance is the productivity of the land, which can vary greatly between pastures depending on species composition, elevation, climatic and soil conditions. The (experimentally determined) stocking density for the particularly thick growths on the Rhoen set stocking pastures lie between 0.8 and 2 LSU ha^{-1}. Investigations on Oeland in Sweden, on the other hand, indicated that the stocking density cannot exceed 0.06 LSU ha^{-1} because of the shallow soils there (cf. Sect. 6.3). On common pastureland grazed all year in Georgia, the level is about 0.3 LSU ha^{-1} and the number of animals is determined more by the summer dry periods and the winter dormancy of the vegetation, and less by soil conditions (cf. Sect. 6.4).

Equally so, the choice of stocking density has to take into account the growth of woody vegetation on the land. Although the set stocking pasture Rotenhauck, with a proportion of woody vegetation of almost 30% of the area, was stocked with only 0.8 LSU ha^{-1}, there were similar results for vegetation height as for on the set stocking pasture Ellenbogen, which was grazed with 1.8 LSU ha^{-1} and was low in woody species. Even if trees and bushes are highly browsed (cf. Sect. 5.3), the woody species only contribute a small part of the nutritional intake in comparison to herbaceous vegetation, so grass swards on areas rich in woody species are used relatively more frequently than areas of the same size but low in trees and bushes.

In the Thuringian Rhoen, the ideal stocking density is achieved with 0.8–1.8 LSU ha^{-1}, where the maximum value represents the upper limit even on very thick growths with low woody vegetation and leads to a relatively early reduction of the vegetation. A stocking density under 0.8 LSU ha^{-1} should not be realized as this would not achieve sufficient reduction of the vegetation (as was observed in the Hemschenberg area in the first year of the investigation) and would lead to encroachment of undesirable species. The values agree with the data from Oppermann and Luick (1999) regarding grazing on productive lowlands which is consistent with nature protection, in which they give a stocking level of 0.8–1.5 LSU ha^{-1}.

Associated with the stocking density and the utilization of the vegetation growth, there are different levels for the occurrence of grazing residues. This can amount to 20–30% of the area for extensive pastures (Oppermann and Luick 1999). But this can occur even with intensive systems of rotational grazing, as was reported by the Chamber of Agriculture Hannover (2004) with 25–30% grazing residue, when in the interest of maximum weight gain efficiency the available grass supply exceeds the uptake capacity. A direct comparison with these figures is difficult because for this current study, a different method was used for the surveying of grazing residues and the proportion of residues was divided into classes. However, as the classes 'none', 'few' and 'medium' formed the largest proportions for all set stocking pastures, except for Hemschenberg in the first year, and the class 'many' (proportions over 50%) only amounted to 2–11%, the overall proportion of grazing residues does not exceed the specified figure of 30%.

Meadows are often classified as particularly valuable with respect to the flora as well as the fauna (for example, Blab 1984; Kapfer 1995; Wilmanns 1998). However, the problem arises for animals which use the meadow that because of mowing, the whole resource and habitat system breaks down within a few hours. Because large areas of meadow are quite often mowed at the same time, a situation of shortage arises and then the only flower-rich, grassy areas are the balks between fields (see Sect. 7.1). As this investigation has shown, large areas of pasture offer a rich availability of flowers over the whole of the vegetation period. On the set stocking pastures with the lowest stocking densities (Hemschenberg, Rotenhauck), the availability of flowers even increased in the course of the summer. It would therefore be sensible to maintain or newly arrange large pastures within meadowlands which can be integrated within the grazing system for the production of winter feed, so that the pastures make up for the temporary shortage situations on the meadows.

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6.3
Spatial Use Patterns for Cattle on Large-Scale Pastures of the Stora Alvaret, Island of Oeland (Southern Sweden)

Inga A. Roedenbeck

6.3.1
Introduction

For the development of specific protection concepts which involve the use of livestock, exact knowledge of the effects and suitability of grazing animals at the spatial level of the whole grazing area is a fundamental requirement (Fischer 2001). In the absence of such knowledge, discussions on the use of livestock to maintain open landscapes are beset with controversy and the effects, compared to other management and stewardship forms, are in part negatively assessed with respect to nature conservation (Blab 1984). Such assessments often have their origins in data collected from modern livestock farming in small paddocks.

Stora Alvaret – the 'Great Alvar' of the island of Oeland (see Chap. 3) is one of the few areas in Central and West Europe in which large-scale grazing regimes (mainly cattle and sheep) have persisted over hundreds of years and even under EU rules are clearly sustainable with traditional farming methods. Ecological research on animal behavior was carried out on a cattle pasture on the southern part of the island. The objective was to shed light on whether cattle can contribute to an increase in habitat diversity relating to the whole area with this degree of spatial availability.

6.3.2
Methodology

The area of the investigation extended over 640 ha from the village of Resmoe in the west of Oeland to the central dividing wall of the Great Alvar (see Chap. 3). Within the period of the investigation from May 03 until September 17, 2002, it was used as a permanent set stocking pasture for 65 young cattle of both sexes, of the breeds SRB (*Svensk rödbrokig boskap* – Swedish Red Cattle) and SLB (*Svensk låglands boskap* – Swedish Holstein Cattle). The very low stocking density of about 0.06 LSU ha^{-1} was a consequence of the extremely low phytomass growth during the summer but was close to the carrying capacity of the land.

For the purpose of positioning the cattle herd within the period of observation – May 9 until September 17, 2002 – two user segments of the Global Positioning System (GPS) were used: a GARMIN-GPS hand device and a telemetric module in the form of a GPS collar (see Sect. 4.3). The determination of position was carried out via the collar in 30-minute cycles and provided 4588 useable positions. In addition, the herd was accompanied on foot over five observation periods made up of three daytime sessions (7:00 A.M.–8:00 P.M.) and three overnight sessions (7:00 P.M.–8:00 A.M.). If the herd repeatedly divided into two to four sub-groups, the largest of these was observed where possible. During each period of observation, the virtual center of the herd was recorded as a geographical position using the portable Garmin-GPS12 at ten-minute cycles. The 2309 usable positions were continually assigned to datasets with the following information elements:

- the total number of visible animals
- the type of behavior of each animal at the corresponding position (Table 6.20)
- the main activity of the herd (behavior in which >50% of individual animals were involved)
- herd formation (maximum herd radius and average individual distances apart) and
- the nearest 'orientation point' including distances up to 100 m (Table 6.21)

Table 6.20.
Mapped behavior types

Behavior type	Summary
Lying – inactive Lying – undifferentiated Lying – ruminating	Inactive
Standing – undifferentiated Standing – ruminating	Standing
Drinking	Drinking
Browsing – grazing Browsing – under trees/bushes Browsing – on trees/bushes	Grazing
Undirected movement	Forward movement
Directed movement	
Other – rubbing Other – grooming Other – dominance Other – defecation Other – social contact	Other

Table 6.21. Each geographical position of the herd was arranged as spatial information where the activity took place within a distance of up to 100 m from a conspicuous structure to which the herd could optically orientate itself in its movements over the pasture. In the absence of any potential orientation structures under 100 m, the category 'open land' was entered for the corresponding coordinate

Orientation structure	Definition
Water source	One of a total of 8 permanent water points on the pasture
Monoliths	Free- lying monoliths of >1 m diameter
Wall	Stone boundary walls
Individual tree/bush	Solitary trees >1.5 m high
Tree islands	Groups of trees/bushes of 2–10 m high (mainly *Picea* and *Pinus*)
Shrub formation	Bush/shrub groups <2 m high (mainly *Potentilla fruticosa* and *Juniperus communis*)
Access gate	Gate through which cattle are driven, beginning of May 2002
Open land	Description assigned for each coordinate in the absence of above macrostructures in <100 m distance to the herd

The determination of the geographical positions was carried out using a GIS (ArcView 3.2®) and georeferenced aerial photographs. The proportion of time that each aspect of behavior occupied each day was calculated as 'herd action' in the unit (min d^{-1}) analogous to Fischer (2001), using the following formula:

$$\mu_{ai} = \sum \frac{Akt_i T_i}{T_{\text{total}}}$$

with:

- μ_{ai} = herd action for behavior *i* per observation day (min d^{-1})
- Act_i = Action per *i* for observation interval (min) (= 10)
- T_i = number of animals involved in behavior *i*
- T_{total} = number of all animals each 10 min observation interval

6.3.3
Results

Pattern of Behavior

The daily routine of cattle is characterized by phases of resting and activity. Both phases alternate with each other and follow rhythmical patterns. The actions of each individual show a high level of agreement with the behavior of the entire herd. Its activity rhythms are synchronized to the activity rhythms of the herd over time (Fig. 6.25).

The general activity rhythms can be differentiated by a spectrum of behavior types which alternate with each other and make up the proportions of the total

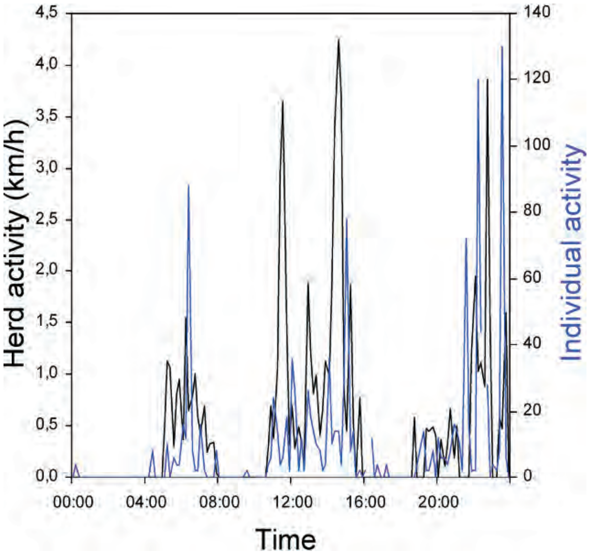


Fig. 6.25. The activity rhythms of individual animals are synchronized to those of the herd over time (July 1, 2002): *black:* herd activity, *blue:* activity of an individual with GPS collar. Individual activity is counted as a dislocation of the collar from the horizontal (up and down movement of the head) (see Sect. 4.3). The herd activity was determined with a GIS as the walking performance of the herd (km h^{-1})

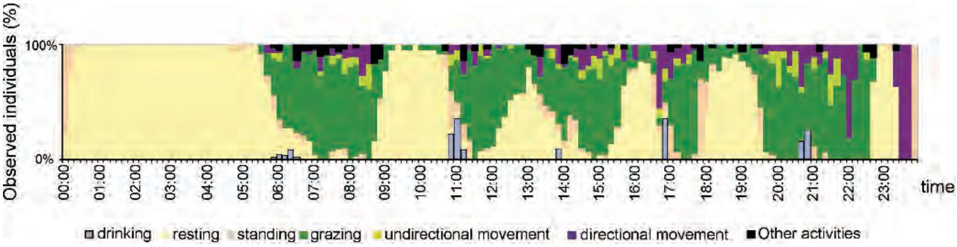


Fig. 6.26. Behavior pattern of the cattle herd on July 21, 2002. The daily routine of the herd is characterized by largely synchronized rest and activity phases

Table 6.22. Time proportion of individual behavior types during the day, calculated as the parameter 'herd action' according to Fischer (2001)

Herd action	Resting	Grazing	Directed movement	Standing	Undirected movement	Drinking	Other	Total
(min d^{-1})	569.8	522.9	121.2	101.5	70.3	26.2	28.2	1 440
(h d^{-1})	9.50	8.71	2.02	1.69	1.17	0.44	0.47	24
(%)	39.57	36.31	8.42	7.05	4.88	1.82	1.96	100

herd behavior (Fig. 6.26). The resting phase for the herd takes up about 570 min d^{-1} and forms the largest proportion with 39.6%. The number of rest periods ranged between one and four with an average of 3.3 per day ($\sigma = 0.704$). Grazing takes up about 523 min d^{-1} with an average of 3.4 grazing periods ($\sigma = 0.793$), making it the second-largest proportion of all behavior types. Grazing and rest periods alternate and are in an indirect ratio to each other. With an increasing proportion of grazing in the total behavior, the proportion spent on rest decreases significantly ($K_p = -0.602$, $p < 0.01$). Drinking formed a very small proportion with about 26 min day^{-1} (1.8%). Drinking events by the herd could be observed between 6:00 A.M. and 9:00 P.M. There was a maximum for this activity between 2:00 P.M. and 3:00 P.M., otherwise it was spread equally throughout the day. With an average walking speed of 314 m h^{-1}, the cattle herd covered an average of 8.07 km d^{-1} and the distances covered during the daytime and night-time observations did not differ significantly from each other (average difference: 88 m, average value comparison: $p = 0.847$).

The category 'forward movement' has to be separated into two characteristics which arise from different behavior groups: *undirected movement* is represented in the behavioral spectrum with 70 min d^{-1} (4.9%). With an average walking speed of 0.88 km h^{-1}, it occurred mainly as an unsynchronized activity and can be assigned to the behavior group for feeding, which shows a significantly positive correlation between the proportion of grazing individuals and those moving forward with lowered head, without feeding ($K_p = -0.217$, $p < 0.001$). On the other hand, the category *directed movement* with an increased walking speed of 1.54 km h^{-1} serves to maintaining contact with the herd or the synchronized search for water sources and night-time resting places (121 min d^{-1}, 8.4%) (Table 6.22).

Impacts on the Grazing Land

Direct impacts on the grazing land could be established for a large part of the types of behavior that the cattle herd manifested in the course of the day.

During *resting* the herd reduced its average spatial extent from 117 m to 71 m ($\sigma = 52.2$ m) (Fig. 6.27). The time that the herd remained in a place correlated positively with the frequency of defecation ($p < 0.001$) (Fig. 6.28). Consequently, 45% of all defecation events take place directly on the resting areas and 63% within a 100 m radius.

Among the factors which influence the structure and form of vegetation and soil during grazing, the main ones are the selectivity and the feeding technique of the grazing

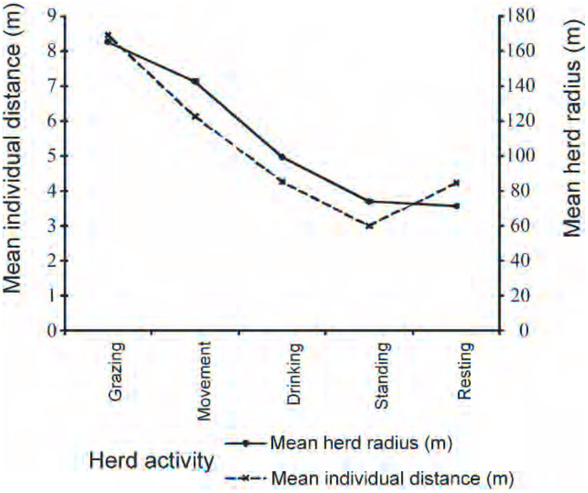


Fig. 6.27. The impacts of resting on the grazing area. The average herd radius has reduced from 117 m to 71 m ($\sigma = 52.2$ m), which contributes to compacting of the soil at the resting area

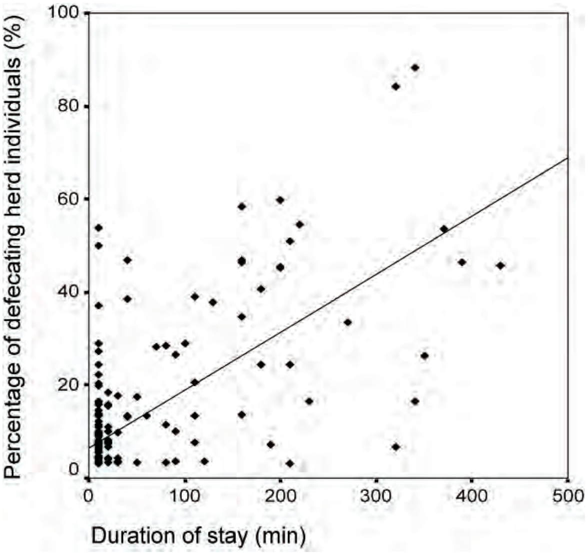
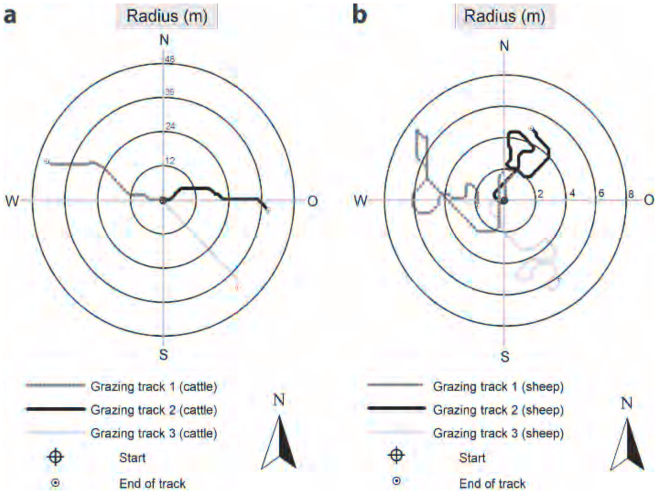


Fig. 6.28. The frequency of defecation for the cattle herd correlates positively with the duration of the stay in a particular place ($K_p = 0.671$, $p > 0.001$)

Fig. 6.29.
A comparison of grazing patterns of **a** cattle and **b** sheep on the Alvar, island of Oeland, using the example of three 10-min periods (July 16, 2002). The exact stepping sequence during grazing was recorded with reference to the points of the compass and entered on a specially prepared mapping card oriented to magnetic north



livestock. These factors are determined by the course of movements during grazing as this establishes the basic pattern of all following effects. Compared to sheep on an adjacent area of 599 ha, cattle have a linear grazing pattern. Within a ten-minute observation interval, they make significantly less changes in direction during grazing than sheep (cattle 9.5 changes, sheep 21.2 changes, $p < 0.001$, $N = 32$ per animal species) and therefore within the same time period, they cover significantly more ground (cattle: 22.9 m, sheep: 7.3 m, $p < 0.001$, $N = 32$ per animal species). Sheep graze attractive sections of ground selectively in narrow loops while cattle move in straight lines over grazing areas (Fig. 6.29).

One of the main impacts arising from cattle in a herd moving forward on a pasture is the effects of trampling. With respect to the average length of pace for cattle of 35.3 cm ($\sigma = 10.7$; $N = 100$ measurements), each animal makes a total of 45 688 hoof prints per day for an average distance of 8 km d^{-1} on the ground or covering vegetation. 65 animals driven onto the pasture will therefore cause a total of about 360 million hoof prints over the whole grazing period, amounting to 560 770 steps per hectare for an area of 640 ha.

Spatial Use Patterns

Every aspect of behavior of the cattle herd was clearly carried out with significant preference to a proximity to particular site structures (Table 6.23). Using an χ^2 analysis, the question was examined as to whether there were increases or decreases in the occurrences of herd visits with specific main activities close to (<100 m) potential 'orientation points' on the pasture (Table 6.21 and Table 6.24).

The results verify that there is a highly significant increase in occurrences of the main activity 'resting' at the access gate ($R_s = 4.2$, $p < 0.001$), near to water sources ($R_s = 2.566$, $p < 0.05$), conspicuous solitary trees ($R_s = 3.054$, $p < 0.01$) and islands of trees ($R_s = 3.103$, $p < 0.01$). Highly significant avoidances were resting places within dense, <1.5 m high bush formations ($R_s = -6.182$, $p < 0.001$) of *Potentilla* and *Juniperus* as well as resting places on open land ($R_s = -2.46$, $p < 0.05$).

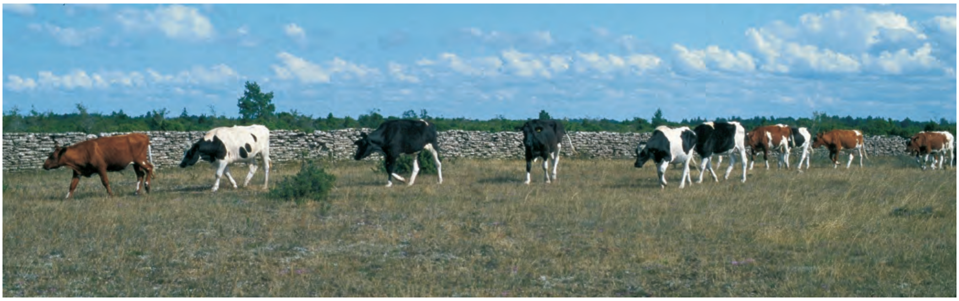


Fig. 6.30. Directed herd movement on an Oeland pasture with targeted orientation along the boundary wall (photo: I. Roedenbeck)

Table 6.23. Behavior-dependent use of structural elements on the pasture – results of the χ^2 analysis according to Pearson. Threshold values for significance levels: −2 and +2 (according to Bühl and Zöfel 2000)

	Resting	Grazing	Forward movement
Patch of woody plants	$p < 0.01$	$p < 0.001$	$p < 0.05$
Solitary woody plant	$p < 0.01$	–	–
Water source	$p < 0.05$	$p < 0.001$	$p < 0.01$
Monolith	–	–	–
Stone walls	–	$p < 0.001$	$p < 0.001$
Other	–	$p < 0.01$	–
Open soil	$p < 0.05$	$p < 0.001$	–
Bush encroachment	$p < 0.001$	$p < 0.001$	–

On the other hand, feeding takes place with a highly significant number of occurrences on open land ($R_s = 4.55$, $p < 0.001$) and in immediate proximity to bush formations ($R_s = 7.05$, $p < 0.001$). Significant avoidances while feeding are for close proximity to potential orientation points on the pasture (Table 6.21): tree islands ($R_s = -3.77$, $p < 0.001$), water sources ($R_s = -4.86$, $p < 0.001$) and walls ($R_s = -4.0$, $p < 0.001$).

For orientation during directed herd movements, the animals use the boundary walls ($R_s = 7.05$, $p < 0.001$). The individual animals form themselves one behind the other like a string of pearls, mainly with the purpose of reaching a water source or night resting place with increased speed (Fig. 6.30).

Clearly, the cattle orient themselves optically with conspicuous site features and have a significant preference for the performance of particular behavior close to particular structural elements. Because the potential orientation points (Table 6.21) on the relatively monotonous vistas of the pasture are all fixed in space and immovable, the whole area is divided into areas in which particular behavior is repeated and carried out largely synchronously. This means that the spatial arrangement of the behavior follows the 'specifications' of the pasture.

Following from this, we find that by the entrance gate and close to conspicuous tree or bush formations, there is a concentration of resting places and, as a consequence of resting

Table 6.24. Behavior-dependent use of structural elements on the pasture – results of the χ^2analysis according to Pearson. ($N = 1682$, χ^2_{Resting}: 153.72, χ^2_{Grazing}: 247.48, $\chi^2_{\text{Forward movement}}$: 72.36). *B:* Observed frequencies (%), *E:* expected frequencies (%), *SR:* standardized residues, *S:* significance

Behavior		Patch of woody plants	Woody plants	Water source	Monolith	Stone wall	Open land	Shrub	Dead-wood	Trans-humance	Miscel–laneous
Resting	B	22.85	16.046	6.162	1.669	0.128	21.566	8.216		14.891	8.472
	E	18.858	12.168	3.979	1.096	0.75	26.067	17.474		10.15	9.458
	SR	3.103	3.054	2.566	1.528	–0.894	–2.46	–6.182		4.153	–2.003
	S	$p < 0.01$	$p < 0.01$	$p < 0.05$	–	–	$p < 0.05$	$p < 0.001$		$p < 0.001$	–
Grazing	B	6.355	2.724	15.045	0.778	8.82	36.057	28.794	0.259		1.167
	E	10.82	4.043	23.543	1.13	14.269	27.467	18.014	0.119		0.595
	SR	–3.769	–1.822	–4.863	–0.918	–4.005	4.551	7.052	1.131		2.063
	S	$p < 0.001$	–	$p < 0.001$	–	$p < 0.001$	$p < 0.001$	$p < 0.001$	–		$p < 0.01$
Movement	B	2.469	19.753	7.407	0	48.148	0	20.988	0		1.235
	E	10.523	27.468	21.522	1.13	16.409	4.043	18.015	0.119		0.773
	SR	–2.235	–1.81	–2.738	–0.957	7.052	–1.325	0.631	–0.31		0.473
	S	$p < 0.05$	–	$p < 0.01$	–	$p < 0.001$	–	–	–		–

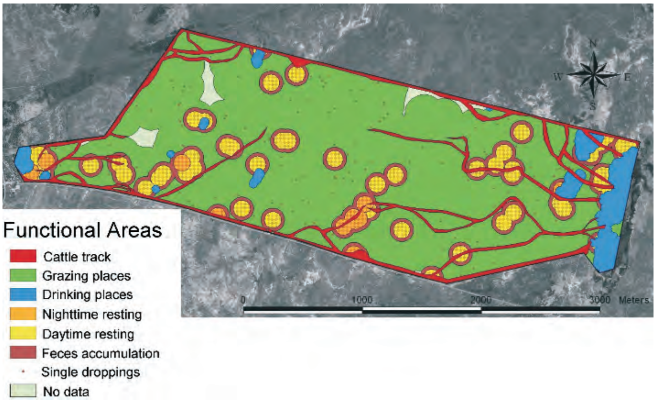


Fig. 6.31. The pasture is sub-divided into functional areas in which the cattle herd prefers to perform particular behavioral activities. The result is a mosaic of structural elements determined by use which forms the character of the area

behavior, an accumulation of dung and shallow resting depressions. On the other hand, cattle trails are mainly found parallel to the boundary wall and close to the water sources. The result of this behavior and pattern of use is a fine-meshed mosaic of structural elements determined by use which in its totality, forms the character of the area (Fig. 6.31).

6.3.4
Discussion

The average duration of grazing determined on the Alvar (feeding time) is, with a minimum of 6.7 h in June and a maximum of 10.7 in August, in complete agreement with the spectrum of results found for different breeds (Forbes and Coleman 1987; Olson and Malachek 1988). According to Moran (1970), the time period needed for feeding is strongly influenced by the condition of the vegetation, so the feeding duration is dependent on the quality of the feed. The large fluctuations in the proportions of time for grazing could be explained by the high variability in the availability of vegetation on the Alvar between May and August. Rosén (1982) confirms this supposition with the evidence that phytomass production on the Alvar in the course of a particularly dry vegetation period can become severely depleted. In a dry summer, as in the year of investigation 2002, the cattle have to adapt their behavior to the vegetation conditions and extend the duration of their feeding time. The average number of 3.4 grazing periods per day is somewhat lower than the figure given for Holstein cows in Virginia of 4 per day (Hardison et al. 1956). A possible reason for a relatively short grazing duration could be overgrazing which does not correspond with the vegetation conditions, according to Hepworth (1991). It could be assumed that the dry summer of 2002 and the restricted availability of feed resulted in overgrazing, despite the low stocking density. The livestock owner confirmed this assumption with oral comments about the poor nutritional state of the animals and their physical development (Åhlund 2004, pers. communication).

The average duration of lying for the cattle breeds SRB and SLB on the Alvar is comparable with figures from other research literature, with 570 min d^{-1}, corresponding to the pattern of shorter lying durations for cattle in extensive systems of farming (Sambraus 1971). In small paddocks (2 ha) and in stalls, the daily lying duration for cows amounts to an average of 600 min and for steers, 700 min (Sambraus 1973). Cattle farming systems with small-scale paddocks or rotational grazing render long walks for the cattle to satisfy their needs unnecessary. The movement activity on the Alvar, with 8.07 km day^{-1} ($\sigma = 2.22$ km), is a particular feature of the Alvar compared to values from research literature (Fischer 2001; Hart et al. 1993). There is clearly a connection between walking performance and the size of the pasture (cf. Sect. 4.2, 6.1, Kostrzewa 2004).

A comparison of the results found here for behavior patterns with those given in literature makes it clear that we are dealing with a special situation on the Alvar because of its spacious pastures. The activity rhythms that were found are characterized with a high degree of regularity and in this sense are typical for cattle (Fischer 2001; Rist and Schragel 1993). Above all, it is particularly noticeable for large pastures that individual animals make a great effort to synchronize with the herd. On small pastures, there is much less synchronization compared with large-scale systems, and animals graze and rest almost continuously in parallel (Sambraus 1973). On the large pastures of the Alvar, simultaneous actions have a significant role in the natural protective behavior corresponding to the ethology of semi-wild ruminant herds (Forbes 1978). Through the high synchronicity and spatial specificity of the behavior, a large number of animals carry out the same actions at fixed times on the same, relatively small locations. Each type of behavior has here characteristic effects on the structure of the pasture as a consequence. Through feed-back interactions, cattle strengthen and modify the natural local conditions and patterns of vegetation growth considerably.

The particular situation on the Alvar can be illustrated clearly with the example of a resting herd of cattle. The natural response to protect against dangers (Kapfer 1995) is expressed in the selection of the resting place. With the objective of being able to recognize predators in the area early and at distance, conspicuous trees which generally grow here on areas of raised ground are selected for the daytime resting place rather than a close proximity to visibility-restricting bushes. This observation is confirmed by Fischer (2001), who showed the preference for raised resting locations rather than places on the surrounding areas. On the pastures investigated in the southern part of Oeland, it was found that at night there was even a preference for stall-like canopied tree islands and for proximity to the entrance point to the land (see Sect. 4.3). The reduced distances between individual resting animals in the selected rest places and the longer residence times of the herd led to a concentration of dung. On small paddocks, a lack of adequate resting places can result in an excessive frequenting of available places. The consequences in such unnatural conditions are a concentration of damage to the grass sward and a build-up of dung and urine in a few areas of the paddock. This results in fallow 'Lägerfluren' or cattle camps, which later attract nitrogen-loving grasses and herbaceous plants (Woike and Zimmermann 1997). This type of ecological overloading is largely avoided on the Alvar because of the large-scale nature of the pastures and the dispersed locations of resting places. The spatial separation of feeding and defecating may also lead to a significant dispersal of nutrients over the pastures and therefore to a diversification of nutrient availability for plants (see Sect. 6.7). As in the case of resting, grazing and trampling are important key parameters for the structural development, and therefore for a characteristic, dynamic spatial-temporal habitat pattern which determines the potential suitability as a habitat for subsequent species (Conradi and Krüger 1999).

Acknowledgments

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6.4
The Effects of Shepherded Cattle Herds on Habitat Structure and Selected Animal Species in Central Georgia

Andrea Bontjer · Benjamin Haerdle

6.4.1
Introduction

The effects of large-scale grazing systems on ecosystems and landscapes in temperate climate zones are particularly well to be investigated in the successor states of the former Soviet Union, in which such systems of farming have persisted over long periods or have become re-established with the introduction of subsistence farming during the period of transformation (Didebulidze and Plachter 2002). This study describes the effects of two shepherded cattle herds on a 150 ha pasture north of Tbilisi (Georgia) (cf. Chap. 3) on the habitat quality of selected species of grasshoppers, birds and reptiles.

6.4.2
Investigation Area and Methodology

The investigation area is located on an isolated plateau mountain (“Zeugenberg”) at the southern edge of the Great Caucasus. The climate is temperate to moderately subtropical with a clear continental influence and characteristic dry summer phase. Precipitation amounts to 500 mm yr^{-1}. Central European livestock breeds are farmed. The area was selected because the grazing regime could be easily documented in the isolated location. The proximity to a monastery suggests that at least part of the area has been used in some form of pasturing, going back to the sixth century and perhaps even earlier. Since 1990, the open land and the small islands of trees have been used as a cattle pasture and before that, the area was used twice a year as a stopover for passing sheep flocks.

In order to record the spatial-temporal dispersion of the cattle, the herd was accompanied once a week during the period of investigation (April to September 1999) and their locations were recorded on a map every 15 min of that day. With the help of a Geographical Information System (ArcView 3.1), a map showing grazing intensity could be drawn up showing the visit frequencies to the various parts as points on the map.

For the assessment of the habitat quality of the formations found here, particular animal species are especially suitable for this purpose. Birds, reptiles and Orthoptera (including grasshoppers, crickets and locusts) were selected as this meant that a particularly wide range of various life forms and requirements profiles could be reflected. While all species of breeding birds were surveyed, two reptile species and thirteen Orthoptera species were selected as ‘indicator species’ with particularly characteristic habitat requirements. These create habitat configurations mainly at the microscale level.

The determination of the Orthoptera species was carried out through comparisons with the collection of the Zoological Institute of the University of Tbilisi and the bird species according to Svensson et al. (1999). The site survey of the species was undertaken using standardized visual observations. For the mapping of the Orthoptera species, a total transect length of 11.5 km was laid across the area on two occasions (once in August over the calendar weeks 31–32 and once in September over the calendar weeks 35–36), for ten days in each case. In this way, all individuals of the thirteen selected species were recorded through visual observation.

The quantitative recording of breeding birds was performed using the standardized breeding bird mapping technique according to Oelke (1967). In this process, at least eight control runs were carried out on transects over the site at regular intervals under standardized conditions (time of day, run speed and weather). The transect routes were laid over the area in such a way that they included a representative selection of all significant habitats. The results were correlated with various parameters, particularly the density and height of vegetation, bush growth density, proportion of open land and exposure.

A mapping run consists of two consecutive mornings. Between May 1 and July 5, 1999, eight mapping runs were carried out at eight-day intervals, in which all types of area-indicative behavior for a breed were recorded on a map. The individual species were differentiated into the groups breeding birds, birds thought to be breeding, visiting feeding birds, and birds passing through. The numbers for breeding birds were sub-divided into four dominance classes: dominant (more than 5% of a species in the total number), sub-dominant (between 2–5%), influent (between 1–2%) and recedent (less than 1%).

6.4.3
Results

Vegetation Types

The present-day vegetation types in the investigation area (IA) have arisen through a long process of zoo-anthropogenic land use. The largest part of IA has a semi-open, steppe-like appearance and is characterized by various xerophilic and semi-xerophilic shrub formations (Shibliak) and *Artemisia* growths (cf. Nakhutsrishvili 1999). There are communities of sparse rock vegetation with a high proportion of cushion plants and dwarf shrubs on stony knolls. The spectrum of plant life is therefore very similar to Central European dry grasslands. Within the IA, there are also various other grassland species on deep-soil and mainly level locations, largely free of woody vegetation. The area consists of two meadows with post-grazing and an intensively used pasture, the whole amounting to about 10 ha. It is characterized by dense, grass-dominated vegetation. Finally, there is a deciduous wood which has clearly been used for a long time as a coppice, and a light afforestation of 15-year-old pine trees. Both areas are grazed.

The intensity of grazing in the investigation area over the vegetation period was determined using the method described in Sect. 4.2. The results turned out to be very diverse, in that overgrazed and undergrazed areas created a close-grained spatial pattern (see Fig. 6.32 and Table 6.25). Overgrazing was found mainly in areas free of bush growths (*Artemisia* steppes, post-grazed meadows). Here, the animals graze for several hours each day, while the bush formations were often only grazed in passing. Very thick bush growths and a pine forest were hardly used as these areas offered the shepherd limited visibility, and in addition, very little herbaceous vegetation can grow under the dense needle canopies. However, these pine trees have an important function for the livestock in providing shade.

Fig. 6.32.
Grazing intensities in the investigation area from April until September 1999, total number of cattle: 130

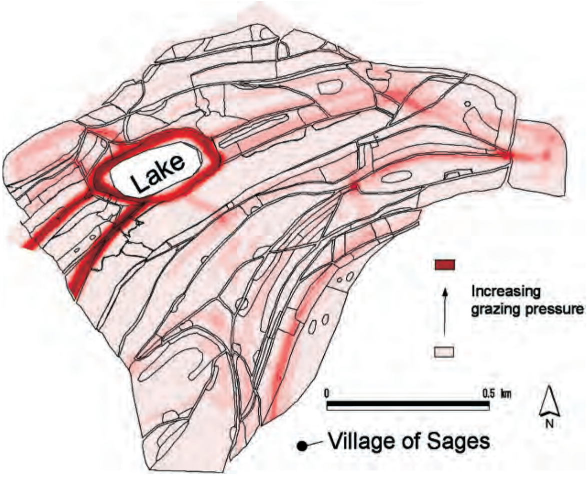


Table 6.25.
Area distribution of grazing intensities in the investigation area. For a calculation of the points, see Sect. 4.3

Points	Grazing intensity	Area proportion in IA (%)
> 200	Very high	1
151 – 200	High	2
101 – 150	Medium	5
51 – 100	Low	14
0 – 50	Very low	78

Grasshoppers

As a consequence of the habitat pattern arising from the type of use, there is a very heterogeneous spatial utilization of wild animal species. Many thermophilic species profit from areas of low-growing vegetation and/or denuded ground habitats. In total, 32 grasshopper and 2 mantid species were recorded in the area. The individual density of the 13 selected species which were mapped on the transect varied strongly within the biotope types and the parameters (Table 6.26).

Calliptamus italicus is the species with the highest individual density in the IA. It is found in large numbers on the intensively grazed open land in the western part of the area (Fig. 6.33).

Decticus verrucivorus has two centers of dispersion: there is a concentration on the post-grazed meadow and the *Artemisia* steppes, both of which have a short vegetation layer. It is absent from biotopes with high bush cover (Fig. 6.34).

Oedipoda caerulescens and *Acrotylus insubricus* are resident in rocky dry areas and other biotopes with light vegetation cover, such as *Artemisia* steppes. In areas with thicker vegetation, they use the cattle tracks and other vegetation-free places which have arisen through the activities of the cattle. *Celes variabilis carbonaria* was only mapped on short-grassed *Artemisia* steppes. The distribution of toad grasshoppers

Table 6.26. Results of the χ^2-test (grasshopper occurrence/environmental parameter) of 13 grasshopper and mantis species based on the transect data, August and September 1999

Species	More individuals than expected for following parameters	Less individuals than expected for following parameters	*p*
Oedipoda caerulescens	Very low and high grazing intensities		0.001
	Shallow soil	No shallow soil	0.001
	Free of vegetation		0.001
	No, low, medium bush cover	High bush cover	0.001
Acrotylus insubricus	Low, medium and high grazing intensity	Very low and very high grazing intensity	0.001
Celes variabilis carbonaria	High grazing intensity		0.001
	No bushes	Medium, high bush cover	0.001
Calliptamus italicus	*Artemisia* steppes Shibliak biotope with low bush coverTemporary grassland	Felsflur Shibliak biotope with medium and high bush cover Intensive pasture	0.001
	Medium, high grazing intensity	Very low, low, very high grazing intensity	0.001
	Shallow soil	No shallow soil	0.001
	Free from vegetation		0.001
	No or low bush cover	High bush cover	0.001
Oedaleus decorus	*Artemisia*-steppes Shibliak biotope with low bush cover	Shibliak biotope with medium and high bush cover, temporary grassland, intensive pasture	0.001
	Average grazing intensity	Low, very high grazing intensity	0.001
	Free of vegetation		0.001
	Low bush cover	High bush cover	0.001
Rivetina baetica	Shallow soil	No shallow soil	0.001
	Low, medium bush cover	High bush cover	0.001
Saga ephippigera	Shallow soil	No shallow soil	0.001
	Medium bush cover	No bushes	0.001
Arcyptera fusca	Shallow soil		0.001
	Low bush cover	High bush cover	0.001
Decticus verrucivorus	Medium, high, grazing intensity	Very low, very high grazing intensity	0.001
	Shallow soil	No shallow soil	0.001
	No, low bush cover	High bush cover	0.001
Decticus albifrons	Very low, low grazing intensity	Very high grazing intensity	0.001
	Shallow soil	No shallow soil	0.001
	Low, medium bush cover	High bush cover	0.001
Mantis religiosa	Medium bush cover	High bush cover	0.01
Tettigonia viridissima	*Spiraea* Shibliak *Paliurus* Shibliak with high bush cover	Felsflur, *Paliurus* Shibliak with low bush cover	0.001
	Medium grazing intensity		0.001
	No shallow soil	Shallow soil	0.001
	Medium bush cover		0.01
Pholidoptera noxia	Shibliak biotope all densities, temporary grassland	Felsflur, *Artemisia* steppes, intensive pasture	0.001
	Low, medium, high grazing intensity	Very high grazing intensity	0.001
	No shallow soil		0.01

Fig. 6.33.
Density distribution of *Calliptamus italicus* in the IA (according to results of two transect runs and estimated values)

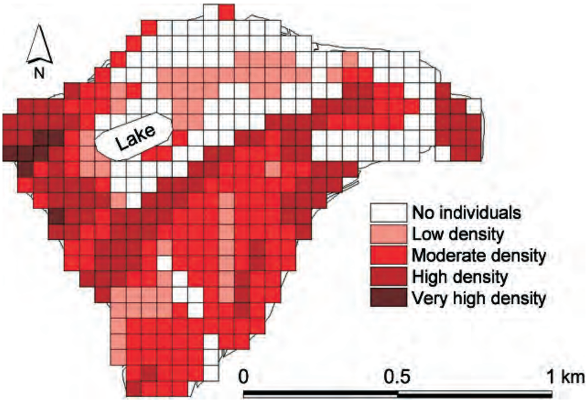
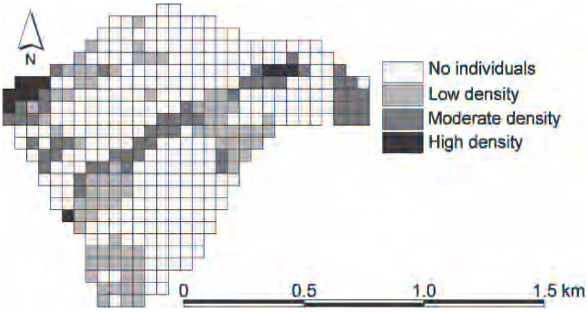


Fig. 6.34.
Density distribution of *Decticus verrucivorus* in the IA (according to results of two transect runs and estimated values)



(Pamphigidae) is similarly narrowly restricted in the area. They were found only in small, completely isolated groups on the rocky knolls which are the most exposed to climate effects (wind, sun and dryness).

Decticus albifrons and *Mantis religiosa* prefer tall-grassed areas and the *Spiraea* Shibliak biotope. The carnivore grasshopper *Saga ephippigera* prefers to use isolated bushes as a base for catching other grasshopper species. The Christ's Thorn dominated Shibliak biotopes offer perfect conditions for this.

The mantid *Rivetina baetica* also finds good conditions on the *Artemisia* steppes, the rock areas and the light Shibliak biotopes to hunt grasshoppers. *Tettigonia viridissima* and *Pholidoptera noxia* occur in almost all biotopes. They are the only species with a high number of individuals to prefer the areas with thicker vegetation.

Birds

A total of 69 bird species were registered, of which 17 were breeding birds and 52 were non-breeding birds (see Table 6.27). The group of non-breeding birds includes 39 species present as visitors seeking food (9 of which were believed to be breeding) and 13 classified as passing migratory birds. The total residence density of the investigation area was 9 breeding pairs (BP) per 10 ha. The highest occurrences were for Lesser Whitethroats (1.8 BP/10 ha), Black-headed Bunting (1.4 BP/10 ha), Common Whitethroat and Corn Bunting (each with 1.1 BP/10 ha) and the Lesser Gray Shrike (0.7 BP/10 ha).

Table 6.27. List of the mapped bird species in the investigation area between May and July 1999 (*B:* breeding bird, *BS:* breeding suspected, *M:* migratory, *F:* food visitor). *B* and *BS:* Completely listed, *M* and *F:* selection

Name	Scientific name	Status	No. of territories	Abund./ 10 ha	Dominance class
Lesser Whitethroat	*Silvia curruca*	B	27	1.8	Dominant
Black-headed Bunting	*Emberiza melanocephala*	B	22	1.4	Dominant
Common Whitethroat	*Sylvia communis*	B	16	1.1	Dominant
Corn Bunting	*Miliaria calandra*	B	12–18	1.1	Dominant
Lesser Grey Shrike	*Lanius minor*	B	9–11	0.7	Dominant
Blackbird	*Turdus merula*	B	9	0.6	Dominant
Great Tit	*Parus major*	B	7	0.5	Dominant
Nightingale	*Luscinia megarynchos*	B	5	0.3	Subdominant
Jay	*Garralus glandarius*	B	4	0.3	Subdominant
Magpie	*Pica pica*	B	3	0.2	Subdominant
Red-backed Shrike	*Lanius collurio*	B	3	0.2	Subdominant
Rock Bunting	*Emberiza cia*	B	2	0.1	Influent
Greenfinch	*Carduelis chloris*	B	1	0.1	Recedent
Common Stonechat	*Saxicola torquata*	B	1	0.1	Recedent
Hoopoe	*Upupa epops*	B	1	0.1	Recedent
Crested Lark	*Galerida cristata*	B	1	0.1	Recedent
Song Thrush	*Turdus philomelos*	B	1	0.1	Recedent
Cuckoo	*Cuculus canorus*	BS	0	x	x
Quail	*Coturnix coturnix*	BS	0	x	x
Ortolan Bunting	*Emberiza hortulana*	BS	0	x	x
Nightjar	*Caprimulgus europaeus*	BS	0	x	x
Orphean Warbler	*Sylvia hortensis*	BS	0	x	x
Garden Warbler	*Sylvia borin*	BS	0	x	x
Grasshopper Warbler	*Locustella naevia*	BS	0	x	x
European Goldfinch	*Carduelis carduelis*	BS	0	x	x
Mistle Thrush	*Turdus viscivorus*	BS	0	x	x
Chiffchaff	*Phylloscopus collybita*	M	0	x	x
Whinchat	*Saxicola rubetra*	M	0	x	x
Blackcap	*Sylvia atricapilla*	M	0	x	x
Wryneck	*Jynx torquila*	M	0	x	x
Grey Wagtail	*Motacilla cinerea*	M	0	x	x
Oriole	*Oriolus oriolus*	M	0	x	x
Bee Eater	*Merops apiaster*	F	0	x	x
Goldcrest	*Regulus regulus*	F	0	x	x
Isabelline Wheatear	*Oenanthe isabellina*	F	0	x	x
Hawfinch	*Coccothraustes coccothraustes*	F	0	x	x
Egyptian Vulture	*Neophron percnopterus*	F	0	x	x
Short-toed Eagle	*Circaetus gallicus*	F	0	x	x
Honey Buzzard	*Pernis apivorus*	F	0	x	x
Raven	*Corvus corax*	F	0	x	x
Roller	*Coracius garrulus*	F	0	x	x

The dominant breeding birds are Lesser Whitethroat, Black-headed Bunting, Common Whitethroat, Corn Bunting, Lesser Gray Shrike, Blackbird and Great Tit. The most frequently occurring breeding bird species are Lesser Whitethroats (*Sylvia curruca*), Black-headed Bunting (*Emberiza melanocephala*), Common Whitethroat (*Sylvia communis*) which were typically almost only found in the bush formations. Only a few breeding pairs could be found in the pine or almond tree woods.

The Corn Bunting was the only species resident in two landscape formations with high numbers and similarly high densities: in the bush formations and the temporary grasslands. 5 breeding pairs of Nightingale were recorded in its typical edge habitat.

Reptiles

In total, there were 137 tortoises (*Testudo graeca ibera*) recorded during the four mapping runs, of which 115 were found in bush formations. It is clear that the main occurrences were in the very lightly grazed areas and the Shibliak areas. No individuals were found on bush-free grassland (Table 6.28 and Fig. 6.35).

Highly significant deviations (χ^2 single test, $p < 0.001$) were found for *Testudo graeca ibera* for the *Spiraea* Shibliak biotope and the edge areas, from a low expectation value. Here, much more individuals were found than were expected. Significantly fewer animals were found in forested areas ($p < 0.01$) and in the deciduous wood ($p < 0.05$).

There were 141 recordings of the Scheltopusik (*Ophisaurus apodus*) over the time of the investigation, of which more than 75% were in the bush formations (Fig. 6.36 and

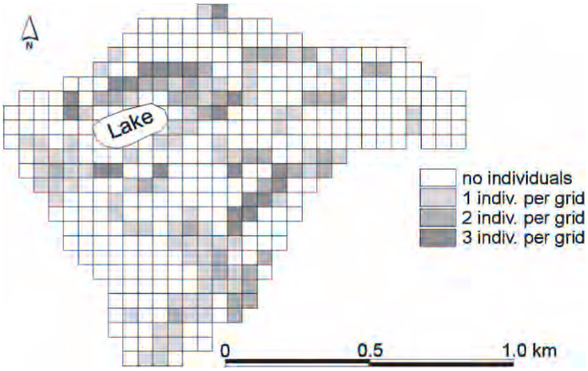


Fig. 6.35. Density distribution of *Testudo graeca ibera* (data from four transect runs and estimated values)

Table 6.28. Visual observations of *Testudo graeca ibera* in the various habitat types

Vegetation type	June	July	August	September	Total
Neglected grassland	1	3	3	0	7
Grassland	0	0	0	0	0
Bush formations	27	28	29	31	115
Woodland	4	6	1	1	12
Forest	2	0	0	0	2
Felsflur	1	0	0	0	1
Total	35	37	33	32	137

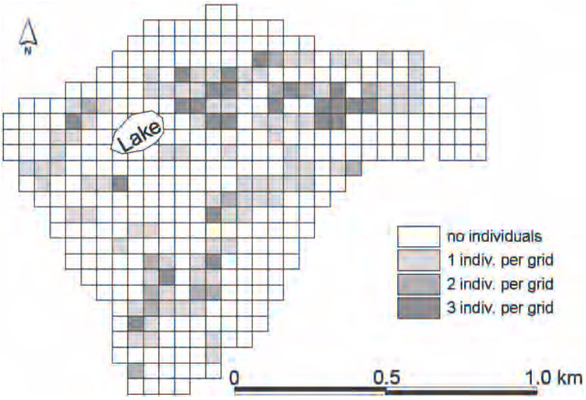


Fig. 6.36. Density distribution of *Ophisaurus apodus* (data from four transect runs and estimated values)

Table 6.29. Visual observations of *Ophisaurus apodus* in the various vegetation types

Vegetation type	June	July	August	September	Total
Neglected grassland	5	1	2	0	8
Grassland	0	0	0	0	0
Bush formations	77	19	4	5	105
Woodland	21	0	0	0	21
Forest	6	1	0	0	7
Felsflur	0	0	0	0	0
Total	109	21	6	5	141

Table 6.29). Similarly, more than 75% of the individuals were found in June. No animals were found on grassland free of woody vegetation.

This species, highly significantly ($p < 0.001$) prefers the edge biotopes and the *Paliurus* Shibliak areas as well as the *Artemisia* steppes ($p < 0.05$). Significantly less ($p < 0.01$) observations were made in the forested areas. Although also in the case of the Scheltopusik, more than a quarter of the individual specimens observed were on lightly grazed areas, more individuals were found than statistically expected also on more heavily grazed areas.

6.4.4
Discussion

The investigation area offers a close-fitting coexistence of various vegetation types. As well as climatic and edaphic factors, the zoo-anthropogenic land use is mainly responsible for generating these habitats. Additionally, the 'controlled' stochasticity of the shepherded grazing impacts reinforces the characterization of the biotopes through specific overgrazing and undergrazing. For example, the decision to graze or not graze slopes threatened with erosion means that erosion processes are exacerbated or prevented through the pasturing system.

The dynamic coexistence of the various stages of succession such as open ground, short-grassed and long-grassed areas, bush formations with different levels of cover and woodland offer favorable conditions for the parallel colonization with numerous species, each with different requirements. While the range of species clearly includes Mediterranean and Continental-Central-Asian elements, it is overall in no way dissimilar to the expected spectrum of species typical of a comparable Central European area (see, for example, the list of bird species). Species such as Black-headed Bunting or the Scheltopusik are replaced here through local equivalents.

Overall, livestock grazing within the investigation area has a positive effect on the Orthoptera fauna. Through the structural variety at the mesoscale, numerous Orthoptera species are able to coexist. Optimal habitat conditions are present for many species. The most important habitats are grassland with a thin cover of vegetation, tall grass steppes with a small degree of fallow growth, semi-open shrub communities, dense shrub communities and special areas free of vegetation (cattle tracks, land slips, rocky areas).

The grazing had different effects on the qualities of these habitats. This is clearly the case for the short grasslands. Through the occurrence of intensive grazing of the plants on the *Artemisia* steppes, which is a factor early in the vegetation period, conditions are created which make it possible for the colonization of xerophilic species with high demands on the structure and the microclimate of their environment, such as *Celes variabilis carbonaria*. The intensive grazing on these areas is actively furthered by the shepherds. If grazing was discontinued, the consequence would be the early disappearance of these species from the investigation area.

Calliptamus italicus is a typical representative of the east Georgian steppes (Stolyarov 1975). These steppes were traditionally used as winter grazing for sheep and are characterized by Christ's Thorn Shibliak and *Artemisia* steppes (Agladze et al. 1999). The western part, in which the highest densities of *C. italicus* occur, were used until 1991 in spring and autumn by migrating sheep flocks. Nowadays, cattle provide a corresponding grazing impact. A small-scale mosaic of neglected grassland, bushes and open land characterizes this area. Brose (1997) describes the same structures for fallow sandy areas in north-east Germany, where the last recorded occurrences of *C. italicus* are documented.

An important factor for the existence of *Decticus verrucivorus* in the investigation area is a short-grassed vegetation cover, which was similarly reported by Hjermann and Ims (1996) for grassland in Norway. Other species such as *Mantis religiosa* and *Decticus albifrons* on the other hand prefer tall-grassed, lightly fallow areas which are seldom grazed. *Pholidoptera noxia* occurs in bushy areas which are not greatly affected by grazing but are, however, protected from a dense scrub encroachment over the long term.

A direct influence of the cattle on the numbers of breeding birds could not be proved. Areas with high and very high grazing intensities were avoided because the conditions for breeding were lacking there. Ground-nesting birds are not found in the area. However, because past grazing intensity has shaped the degree of cover of the characteristic shrub varieties (above all, *Paliurus spina-christi*) and with that, the overall extent of scrub encroachment of the investigation area, there is an indirect impact of the grazing regime on the bird fauna.

The total density of colonization on the IA was calculated to be 9 breeding pairs (BP) per 10 ha. This value lies just under the values found by Flade (1994) for semi-open, richly-structured landscapes in Northern and Central Germany of 10 BP/10 ha on areas of comparable size. Thorny bushes such as Christ's thorn and hawthorn offer potentially favorable nesting possibilities. The Christ's thorn reaches a height of up to 4 m in the IA but the effects of cattle through rubbing and breaking off of branches extend only to 1.5 m so that nests built high up are not disturbed.

Testudo graeca ibera has a distribution concentration on very lightly grazed areas where almost 90% of the individuals were found. Tortoises react sensitively to grazing, according to Berry (1978). Above all, juvenile animals are directly threatened by trampling. This could explain why no tortoises were found on bush-free areas. The animals were mainly found in cracks in rocks or sitting in shrubs. Tortoises, therefore, prefer the richly structured bush formations which are currently exposed to a low grazing pressure but will be maintained in this form over the long term. An abandonment of livestock farming in the investigation area would in the long term lead to the encroachment of tree species and therefore a deterioration of the habitat for *Testudo graeca ibera*.

In comparison to *Testudo graeca ibera*, *Ophisaurus apodus* has a higher grazing tolerance. The reasons for this are on the one hand, its ability to react relatively quickly and on the other, its much higher flight distance (cf. Gans and Gasc 1989). For the Scheltopusik, the availabilty of secure hiding places is important to allow escape from passing dangers. In the investigation area, therefore, it prefers habitat types dominated by Christ's thorn. The semi-open areas arising from the actions of cattle are important for *O. apodus* feeds on snails, grasshoppers and beetles. The low observation rates in high summer could be explained by a summer diapause similar to those in comparable geographical regions such as has been described for Dagestan (Petzhold 1995).

Acknowledgments

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6.5

The Impacts of Different Grazing Variants on Selected Invertebrates in a Low Mountain Range in Germany (Rhoen)

Nanette Hänsel

6.5.1

Introduction

Findings on the ecological impacts of livestock grazing in semi-open mosaic landscapes have previously concentrated mainly on the grazing intensity or on comparisons between (modern) grazing and mowing systems (cf. Erhardt 1985a; Fricke and von Nordheim 1992; Kiechle 1994; Rambo and Faeth 1999; van Wingerden et al. 1991, 1992; van Wingerden et al. 1992; von Nordheim 1992; Wettstein and Schmid 1999). However, the question as to the extent to which the size of the individual pastures and the interconnected complexes of pastures play a role with respect to species variety is still open (cf. Bontjer and Plachter 2002). This is particularly the case for the impacts on the populations of invertebrate species.

In this section, the spatial structure of the occurrences of selected invertebrate species (butterflies and grasshoppers) on various cattle pastures in the Hessian and Thuringian Rhoen are comparatively investigated. The working hypothesis is that through the stochastic disturbance regime, large-scale livestock grazing offers a better possibility of maintaining or recreating a high biodiversity on grassed ecosystems and in park-like mixed landscapes, compared to other management systems currently used in such areas.

6.5.2

Methodology

Site Surveys

None of the investigation areas had been fertilized for a long time and were grazed with cattle in a moderately intensive form. The areas differ from each other mainly through the forms of grazing (continuous or rotation) and area size (cf. Table 6.30), so that the impacts of different grazing variants (large-scale set stocking (Thuringia) and small-scale rotations (mainly Hesse and in part, Thuringia)) could easily be compared.

In 2001, (Hesse, end of June until the middle of August) and 2002 (Thuringia, the middle of July until the beginning of September) a survey of the grasshoppers and butterflies on a total of ten investigation areas was carried out, with in each case, two survey runs of 20-minute durations (visual observation, listening and netting). These were mainly areas with grazing-induced habitat types relevant to the investigation (fresh mesophilic grassland (meso-GL), dry, calcareous grassland (calcareous-GL), wet grasslands (wet-GL), grazing residues, shrubs, bushy areas, open ground and stony areas) ($N = 169$).

The grassland growths (meso-GL, wet-GL and calcareous-GL) were observed walking along a loop (cf. Bruckhaus and Detzel 1997; Erhardt 1985a; Pollard 1977; Settele

Table 6.30. Short characterization of the investigation area. Grazing form: *SS:* set stocking, *RP:* rotational pasture; state: *TH:* Thuringia, *HE:* Hesse; investigation areas: *ELLE:* Ellenbogen, *HEMS:* Hemschenberg, *LICH:* Lichtenau, *ROTE:* Rotenhauck, *THAI:* Thaiden, *SEIF:* Seiferts, *MELP:* Melperts, *WÜST:* Wüstensachsen; for abbreviation of habitat type: see text. Because of a high area representation, spot samples were taken for objects of the same habitat type for each investigation area. *n.u.:* not investigated. In Thuringia, in 2002 there were partial extensions to the pasture area compared to 2001, marked with ^{a} in the table

	Habitat	Study site										Sum
		ELLE		HEMS	LICH	ROTE		THAI	SEIF	MELP	WÜST	
Grazing type		SS	RP	SS	SS	SS	RP	RP	RP	RP	RP	
Region		TH	TH	TH	TH	TH	TH	HE	HE	HE	HE	
Mean elevation (m a.s.l.)		760	720	600	580	540	520	620	680	720	800	
Exposition		NW	NW	NO, O, SO, S	SW	O, SO, SW,W	SO, S	W	W	W	NW, SW	
Total area (ha)		37	7	25	50^a	20	6^a	58	71	61	118	453
Paddock size (ha)			7.0				6.0	4.1, 9.0	4.9, 13.6	10.4, 11.3	6.7, 11.8	
Stock (LSU ha^{-1})		1.8	1.4	0.5	1.0	0.8	1.2	1.2	1.0	1.3	1.4	
Number habitat samplings/plot	Meso-GL	8	7	8	8	8	6	4	4	4	3	60
	Wet-GL	2	2	2	2	0	0	2	2	3	2	17
	Meager-GL	2	0	2	0	2	2	2	2	2	1	15
	Pasture remainders	2	2	2	2	2	2	–	–	–	–	12
	Shrubs	2	2	2	2	2	2	2	2	1	1	18
	Bush encroachment	2	2	2	2	2	2	3	2	2	1	20
	Open soil	2	2	2	2	2	2	2	2	2	1	19
	Stones	0	0	0	0	0	0	3	2	2	1	8
Sum habitat samplings/plot		20	17	20	18	18	16	18	16	16	10	169

Table 6.31. Surveyed environmental parameters in the investigation areas. Environmental parameters which are shown in brackets were not surveyed or measured

	Unit/classes	
Abiotic environment, climate		
Weather	1 = very cloudy 2 = cloudy	3 = slightly clouded/sunny 4 = sunny
Wind force	1 = calm 2 = moderately windy	3 = windy 4 = very windy
Air temperature	°C	
Humidity	%	
Soil moisture	1 = very dry 2 = mostly dry 3 = intermediate	4 = mostly moist 5 = very moist, wet
Percentage of stones in habitat type	0 = no stones <10% = occasionally 10–50% = moderately	50–90% = many >90% = a great many
Pasturing		
Active utilization	1 = before grazing 2 = during grazing	3 = after grazing
Feeding traces	0 = no traces <10% = few 10–50% = moderate	50–90% = considerable >90% = a great many
Trampling traces	1 = no or few traces 2 = occasional 3 = moderately	4 = many 5 = a great many
Dung	1 = no dung 2 = occasionally 3 = little	4 = much 5 = very much
Resting places	1 = no resting places 2 = scattered	3 = continuous (>50%)
Vegetation		
Vegetation cover	In classes of 10%-steps	
Vegetation height	0–5 cm = extremely short 5–15 cm = very short 15–30 cm = short	30–50 cm = moderately high 50–70 cm = high >70 cm = very high
Flower density	1 = no flowers 2 = few flowers 3 = moderate	4 = many flowers 5 = a great many flowers
Spatial resistance	1 = open, no vegetation 2 = single halms 3 = moderately N° of halms	4 = many halms 5 = a great many halms
Homogeneity (combination of vegetation height and vegetation cover)	1 = very homogeneous 2 = homogeneous 3 = moderately homog./diverse	4 = little homogeneous 5 = very diverse
Pasture remnants	0 = no remnants <10% = few 10–50% = moderate	50–90% = many >90% = a great many
Degree of encroachment within habitat type	1 = no woody plants 2 = few, some 3 = moderately	4 = many 5 = a great many

et al. 1999). The remaining, in part much smaller habitat types (grazing residues, shrubs, bushy areas, open ground and stony areas) were surveyed by walking through them, according to the time available. As well as the grazing parameters (stocking number, intensity of grazing effect, hoof prints in ordinal scales), parameters for vegetation structure, location and climate were recorded (Table 6.31).

In contrast to other investigations, the analyses were carried out based on the parameter for number of livestock (LSU per hectare and grazing period) rather than stocking density (actually the number of grazing animals at a specific point in time per ha; Oppermann and Luick 1999), in order to give sufficient consideration to the effects of grazing on spatial structure over a longer time period and therefore potentially on the variety of species. The work on site took place only in conditions of sunny to lightly cloudy weather with at least 17 °C air temperature and no wind to light winds (cf. Settele et al. 1999).

Evaluation of the Findings

The grasshopper and butterfly species that were found were summarized into groups with similar habitat requirements (ecological groups), in accordance with data from the literature (cf. Beinlich 1995; Plachter 1989) (see Table 6.32, 6.33) and assigned to the different grazing variants. The species were then classified into frequency classes, with reference to Erhardt (1985b) and Marchand (1953) (very seldom up to large numbers; for threshold values of frequency classes). The diversity of species in the investigation areas was calculated using the Shannon Index and evenness in accordance with Mühlenberg (1993).

In order to analyze the basic relationships between species or species communities and environmental parameters (grazing, vegetation structure, habitat type, location, and climate), a Canonical Correspondence Analysis (CCA) was carried out with the help of the computer program 'Canoco for Windows 4.5'. The objective of this analysis was the identification of the measured parameters which are substantially responsible for the distribution of species over the investigation areas. The first axis (horizontal) always gives the main direction of the variations in the species composition explainable through environmental variables. The second and the following axes display the residual variation. The environmental parameters represented as arrows indicate the direction in which the species composition changes maximally in correlation to the actual environmental parameter. The relative length of the arrow to the axis is therefore a measure of the quality of the correlation to the ordination axes (Jongman et al. 1995), which are expressed with the coefficient *r*.

Because primary grazing parameters affecting species distribution were to be investigated, location and climate parameters (TH/HE, 2001/2002, exposure, height above sea level, weather, wind strength, air temperature and humidity) were included in the analysis as co-variables. Redundant environmental parameters which were without significance for the variance in the species composition were not included ('forward selection'). In addition, species with very small individual numbers, or 'vagrants', were not considered because of possible distortions to the analysis. The abbreviations of the species names and the environmental parameters in the diagrams can be taken from Tables 6.31–6.33.

Table 6.32. Grasshopper communities in the investigation area, divided into ecological groups (cf. Beinlich 1995). *SS:* Set stocking, *RP:* rotational pasture, *RL D:* red list status Germany (BfN 1998), *RL He:* red list status Hesse (Grenz and Malten 1996), *RL Th:* red list status Thuringia (Jedicke 1997). Target species *X:* target species are all selected species in the Bavarian Rhoen, which have priority status for preservation and support (Altmoos 1997). Investigation areas: *ELLE:* Ellenbogen, *HEMS:* Hemschenberg, *LICH:* Lichtenau, *ROTE:* Rotenhauck, *THAI:* Thaiden, *SEIF:* Seiferts, *MELP:* Melperts, *WÜST:* Wüstensachsen. Division in classes according to individual frequency: 1–2 ind. = r (very rare); 3–4 ind. = + (rare); 5–8 ind. = 1 (scattered); 9–16 ind. = 2 (fairly frequent); 17–32 ind. = 3 (frequent); 33–64 ind. = 4 (very frequent); ≥65 ind. = 5 (common, large numbers)

Species	Abbr.	RL D	RL He	RL Th	Target species	ELLE SS	ELLE RP	HEMS SS	LICH SS	ROTE SS	ROTE RP	THAI RP	SEIF RP	MELP RP	WÜST RP
Xero-thermophilic open land species															
Chorthippus brunneus	ChorBrun										1				
Myrmeleotettix maculatus	MyrmMacu											1	1	2	+
Stenobothrus lineatus	StenLine		V					3			2		1	1	
Tetrix bipunctata	TetrBipu		3									2	r		
Tetrix undulata	TetrUndu			3				r							
Species of extensive grassland															
Isophya kraussi	IsopKrau		3		x								1		
Metrioptera brachyptera	MetrBrac		3		x	r					1				
Species of intensive grassland															
Chorthippus albomarginatus	ChorAlbo						3	3	4						
Chorthippus biguttulus	ChorBigu					4	r	5	4	5	5	5	5	5	r
Chorthippus parallelus	ChorPara					5	5	5	5	5	5	5	5	5	2
Metrioptera roeseli	MetrRoes					2	3	3				1	4	4	1
Omocestus viridulus	OmocViri					5	5	5	5	5	5	5	5	5	5
Species of the tree and shrub layer															
Pholidoptera griseoaptera	PholGris					1	4	2	3	4	2	1	2	1	r
Tettigonia cantans	TettCant									r		r	+	+	
Tettigonia viridissima	TettViri						r	r		1					
Number of species						6	7	9	5	6	7	8	10	8	6
Shannon index						1.06	0.99	1.15	0.91	1.05	1.01	1.31	1.64	1.56	0.89
Evenness						0.59	0.51	0.52	0.56	0.59	0.52	0.63	0.71	0.75	0.49

Table 6.33. Butterfly communities in the investigation areas, divided into ecological groups (in accordance with Settele et al. 1999). *SS:* Set stocking, *RP:* rotational pasture. *RL D:* RL status Germany (BfN 1998), *RL He:* RL status Hesse (Kristal and Brockmann 1996), *RL Th:* RL status Thuringia (Jedicke 1997). Target species *x:* target species are all selected species in the Bavarian Rhoen, which have priority status for preservation and support (Altmoos 1997). Investigation areas: *Elle:* Ellenbogen, *Hems:* Hemschenberg, *Lich:* Lichtenau, *Rote:* Rotenhauck, *Thai:* Thaiden, *Seif:* Seiferts, *Melp:* Melperts, *Wüst:* Wüstensachsen. Division in classes according to individual frequency: 1 ind. = r (very rare); 2 ind. = + (rare); 3–4 ind. = 1 (scattered); 5–8 ind. = 2 (fairly frequent); 9–16 ind. = 3 (frequent); 17–32 ind. = 4 (very frequent); ≥33 ind. = 5 (common, large numbers)

Species	Abbr.	RL D	RL He	RL Th	Target species	ELLE SS	ELLE RP	HEMS SS	LICH SS	ROTE SS	ROTE RP	THAI RP	SEIF RP	MELP RP	WÜST RP
Xero-thermophilic open land species															
Polyommatus coridon	PolyCori							+							
Mesophilic open land species															
Aphantopus hyperantus	AphaHype					3	3	2	2	4	+	2	r		
Coenonympha pamphilus	CoenPamp							2		1	2	1	r	2	1
Colias hyale	ColiHyal		3	3			r		r		+				
Hesperia comma	HespComm	3	2	3				r							
Lasiommata megera	LasiMege		V			r		r		2	+			r	
Lycaena phlaeas	LycaPhla					r	r			+		r			r
Melanargia galathea	MelaGala					r	r	5		2	2		r		
Papilio machaon	PapiMach	V	V					1			1	r			
Thymelicus lineola	ThymLine							r	r		r				
Hygrophilic species															
Boloria selene	BoloSele	V	2		x										1
Melitaea diamina	MeliDiam	3	2											+	
Xero-thermophilic wood-dwelling species															
Lasiommata maera	LasiMaer	V	2											r	
Boloria dia	BoloDia	3		3						r	r				

Table 6.33. *Continued*

Species	Abbr.	RL D	RL He	RL Th	Target species	ELLE SS	ELLE RP	HEMS SS	LICH SS	ROTE SS	ROTE RP	THAI RP	SEIF RP	MELP RP	WÜST RP
Mesophilic species of transition zones rich in woody plants (and of edges)															
Argynnis aglaja	ArgyAgla	V	3												+
Gonopteryx rhamni	GonoRham					+	1		r	r					
Leptida sinapis	LeptSina	V	V	3				r	1	r	r				
Lycaena tityrus	LycaTity	V	2						r						
Polyommatus semiargus	PolySemi	V	V	3				r					r	r	+
Thymelicus sylvestris	ThymSylv							3	3	3	+		3	+	
Thecla betula	ThecBetu									r					
Mesophilic forest species (inhabitants of inner and outer edges and forest skirts)															
Araschnia levana	ArasLeva						r		2		1				
Argynnis paphia	ArgyPaph		V							r					
Erebia ligea	ErebLige		3										+		
Pararge aegeria	ParaAege						+	+				r	r		
Polygonia c-album	PolyCAlb								r						
Ubiquists															
Aglais urticae	AglaUrti					4	4	3	4	4	1			1	1
Inachis io	InacIo					5	3	2	5	2	+		1	r	2
Maniola jurtina	ManiJurt					3	3	5	4	5	5	2	r	1	1
Ochledes sylvanus	OchlSylv													r	
Pieris brassicae	PierBras					1		2	+		+	r			
Pieris napi	PierNapi					4	4	5	5	5	3	2	1	1	2
Pieris rapae	PierRapa						1	4		3	1				
Polyommatus icarus	PolyIcar					r		2		1	3	r		2	r

6.5.3
Results

Species Frequency and Diversity

In total, there were 15 grasshopper and 36 butterfly species identified. With respect to the grasshoppers, more species could be found mainly on the rotation pastures (UW) than on the set stocking pastures (SW) (with the exception of SW Hemschenberg) (Table 6.32). On the other hand, butterflies occurred in higher numbers on set stocking pastures (with the exception of UW Rotenhauck) (Table 6.33).

The Shannon-Wiener-Index and the evenness indicate for both grasshoppers and butterflies the highest values on the rotation pastures in the Hessian Rhoen (with the exception of UW Rotenhauck in Thuringia). For the grasshoppers in the Hessian Rhoen, these index values were a result of both the higher species numbers and the more equal individual distribution. On the other hand, the values for butterflies are a consequence of the equal distribution of the individuals alone.

The xero-thermophilic grasshopper species (e.g., *Myrmeleotettix maculatus*, *Stenobothrus lineatus*) are mainly found in the Hessian Rhoen and the UW Rotenhauck (Thuringia) (Table 6.32). On the other cattle pastures of the Thuringia Rhoen, species from this ecological group are found only sporadically. The species distribution of the other ecological groups (mainly species of the farmed grasslands and the tree and bush layers) is otherwise similarly represented on the set stocking and rotation pastures. Clear differences in the individual frequencies could also not be statistically shown.

For the butterfly communities (Table 6.33), species of all ecological groups were represented in the investigation area, independent of grazing variants. The dominant species, apart from the ubiquists, were mainly mesophilic species of open land (e.g., *Lasiommata megera*, *Melanargia galathea*) and species from edge habitats (e.g., *Polyommatus semiargus*, *Thymelicus sylvestris*). On the Thuringian areas, more species from the named ecological groups (mesophilic species of open land and species of edge habitats) could be recorded, which explains the higher species numbers in comparison to the rotation pastures of the Hessian Rhoen. Here too, no clear differences in the individual frequency between the different grazing variants could be found.

Spatial Structure of Invertebrates Dependent on Grazing Parameters

The variance in the species composition or in the distribution of species in the investigation areas has for both grasshoppers and butterflies no significant relationship to the parameters applying in the grazing regimes (large or small pastures, set stocking or rotation pastures, number of livestock).

For grasshoppers (Fig. 6.37), the determining parameters for the variation in the species composition are individual habitat types and vegetation structures (1^{st} axis: eigenvalue = 0.297; Monte Carlo permutation test (MCP): F value = 27.11; $p < 0.01$).

The variations are therefore mainly explained through the habitat type ‘bushy areas’ (1^{st} axis $r = 0.75$; cf. Table 6.34). Primarily, *Pholidoptera griseoaptera* could be recorded here. The remaining species were identified outside of this habitat. The dry calcareous grassland represents a further important environmental variable for species variation

Fig. 6.37.
Canonical Correspondence Analysis (CCA) of grasshoppers from a dataset with 124 records and in total twelve species considered. No unusual species or vagrants are included. The 1st and 2nd axes are shown. Eigenvalue 1st axis: 0.297; 2nd axis: 0.130; 3rd axis: 0.056; 4th axis: 0.035. Abbreviations used are explained in Tables 6.31 and 6.32

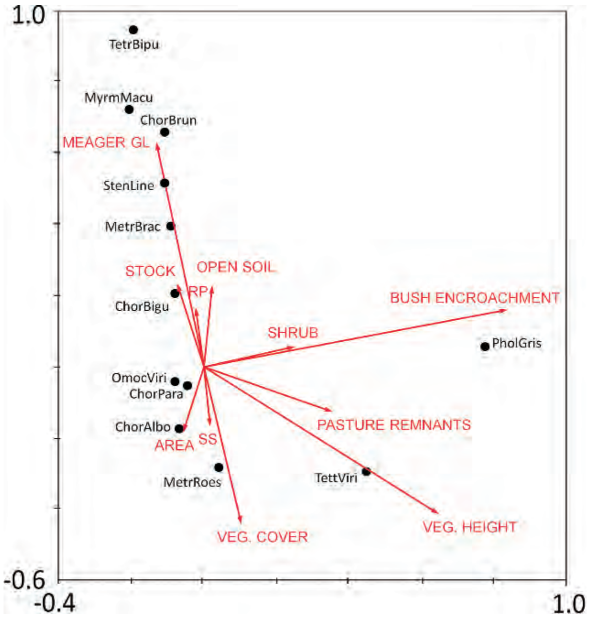

Table 6.34.
Correlation of the environmental parameters with the axes 1–4. Data for correlation coefficients *r*. For abbreviations of the environmental parameters, see Table 6.31

	Axis	Axis	Axis	Axis
Grasshoppers				
SS	0.02	–0.19	0.12	0.11
RP	–0.02	0.19	–0.12	–0.11
Area	–0.07	–0.21	0.15	0.25
Stock	–0.09	0.26	–0.06	–0.31
Meager grassland	–0.12	0.52	–0.31	0.11
Pasture remnants	0.32	–0.10	0.07	–0.01
Shrub	0.23	0.05	–0.01	0.01
Bush encroachment	0.75	0.12	0.01	0.06
Open soil	0.02	0.18	0.32	–0.04
Vegetation cover	0.11	–0.37	–0.36	–0.05
Vegetation height	0.59	–0.33	–0.01	–0.03
Butterflies				
Use	–0.12	–0.27	0.41	0.10
Meager GL	–0.47	0.10	–0.07	0.27
Pasture remnants	0.31	–0.24	–0.27	0.23
Bush encroachment	0.29	0.33	0.22	0.20

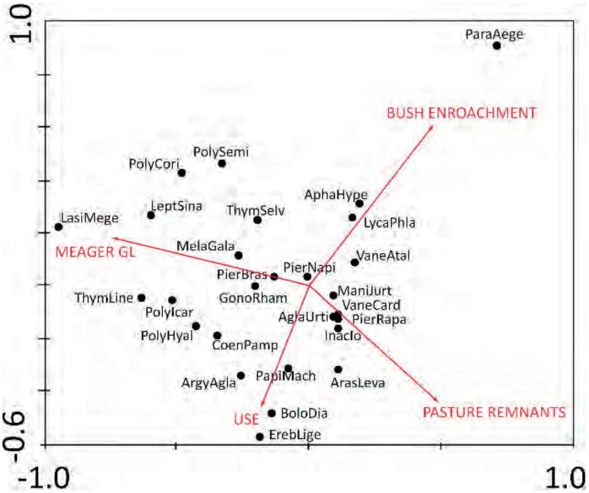

Fig. 6.38.
Canonical Correspondence Analysis (CCA) of butterflies from a dataset of 113 records and in total 28 considered species. No rare species or vagrants are included. The 1st and 2nd axes are shown. Eigenvalue 1st axis: 0.102; 2nd axis: 0.074; 3rd axis: 0.054; 4th axis: 0.042. Abbreviations used are explained in Tables 6.36 and 6.38

(2nd axis: $r = 0.52$). Only species such as *Tetrix bipunctata*, *Stenobothrus lineatus* and *Myrmeleotettix maculatus* which prefer dry areas are found here. For the vegetation structures, vegetation height and cover are similarly of importance and have a significant impact on species composition in the investigation areas (veg. height, 1st axis: $r = 0.59$ and veg. cover, 2nd axis: $r = -0.37$). The vegetation height is therefore induced by the grazing activity of the cattle (Spearman correlation, $N = 169$, $r = -0.28$, $p < 0.001$) and is in a close relationship to spatial resistance (Spearman correlation, $N = 169$, $r = 0.89$, $p < 0.001$). On the other hand, parameters of the grazing regimes such as set stocking or rotation grazing (4th axis: $r = -0.11$ and $r = 0.11$ respectively), stock numbers (4th axis: $r = -0.31$) or the size of the area (4th axis: $r = 0.25$) have only a minor relevance for species variation on the investigated cattle pastures.

For the butterflies (Fig. 6.38), the environmental parameters responsible for species variation were not so easy to determine as in the case of the grasshoppers. The most important environmental variables are again the different habitat types (1st axis: eigenvalue = 0.102; MCP: F value = 2.935; $p < 0.05$). The dry, calcareous grassland explains here the main part of the variations (1st axis: $r = -0.47$). The only xero-thermophilic species found here was the Chalkhill Blue (*Polyommatus coridon*). Mesophilic species of open land (e.g., *Lasiommata megera*, *Thymelicus lineola*) and species from bushy areas (e.g., *Leptida sinapis*) were also found.

The flower availability in the dry, calcareous grassland is clearly higher than in the other habitat types, similarly to the situation for grazing residues (H-test, $\chi^2 = 88.739$; $df = 7$; $p < 0.001$) and the grazing structure of the cattle in comparison to the other habitat types is similarly high. Grazing impacts and quantative flower availability therefore do not correlate for butterflies (Spearman correlation, $N = 169$, $r = 0.07$, $p > 0.05$). The higher flower availability affected both *(a)* the number of butterfly individuals and also *(b)* the number of butterfly species (Spearman correlation; $N = 169$; *(a)* $r = 0.62$; $p < 0.001$; *(b)* $r = 0.63$; $p < 0.001$). In addition, bushy areas (2nd axis: $r = 0.33$) and, to a lesser extent, grazing residues (3rd axis: $r = -0.27$) are of significance.

In the bushy areas, the most common species was the mesophilic woodland species *Pararge aegeria* (Speckled Wood). The flower-rich grazing residues were on the other hand used mainly by ubiquitists. One grazing parameter, the current use of the pasture (see Table 6.31) had furthermore a certain impact on the variation in species composition (3^{rd} axis: $r = 0.41$). Although the pastures were already grazed at the time of the survey, the species *Erebia ligea*, *Boloria dia*, *Argynnis aglaja* and *Papilio machaon* could be found. With the exception of *P. machaon*, there were mainly inhabitants of edge habitats like woodland edges.

A further ordination analysis with all measured environmental parameters (also co-variables = location and climate parameters) proved that the location and climate parameters have a much greater significance for the variance in the species composition (1^{st} axis: eigenvalue = 0.271, 2^{nd} axis: eigenvalue = 0.158) than the other defined environmental variables. Here, the exposure is the decisive factor (expressed as east-facing areas exposed to the east, south-east or north-east; 1^{st} axis: $r = 0.48$), which explains the species composition. Significant differences concerning *(a)* individual and *(b)* species occurrences for each exposure could be established (H-test, $\chi^2 =$ *(a)* 15.059 and *(b)* 14.830; $df = 6$; $p < 0.05$). In addition, the different investigation areas in Thuringia and Hesse (2^{nd} axis: $r = -0.44$ (TH) and $r = 0.44$ (HE) and the height above sea level (1^{st} axis: $r = -0.36$) have a large to medium impact on species variation. However, with the exception of 'current use', the grazing parameters play no role in the classification and statistical preparation used here for the distribution of butterflies in the investigation area. The vegetation structure is significantly determined by the use as a pasture.

6.5.4
Discussion

In the case of grasshoppers in this investigation, the existence of different habitat types in close proximity (bushy areas, dry, calcareous grassland) and the spatial structure of the vegetation (vegetation height and cover, spatial resistance) are of prime significance for the spatial distribution of the species investigated. The form of some of these parameters is also, or even mainly, dependent on the grazing regime. Locational differences (height above sea level) also play an important role. However, direct effects of different grazing variants could not be proved statistically. These findings are in line with the observations of other researchers. According to this study, grasshoppers are characterized among other things by a high affiliation to the habitat type, which is mainly affected by the nature (spatial structure) of the vegetation (cf. Fricke and von Nordheim 1992; Kriegbaum 1989; Sänger 1977). Through the vegetation, the micro-climate and spatial structure are determined, on which the individual species are variously adapted.

The structure of the vegetation, formed through grazing management (ranging from no cattle grazing up to intensive grazing), had immediate impacts on the abundance of several selected grasshopper species on a naturally short-grassed prairie in Colorado (Capinera and Sechrist 1982). In a later investigation over several years, the grasshopper fauna on an unfertilized, fertilized and/or with herbicide treated cattle pasture were surveyed (Capinera and Thompson 1987). Within the species diversity, no significant differences could be established and the individual occurrence of selected species observed over several years was subject mainly to climatic factors (temperature and precipitation in the months from June to September; cf. also Kingsolver 1989).

Wettstein and Schmid (1999) proved a positive correlation for both species occurrence and the density of species per unit of investigation area with respect to grasshoppers and the vegetation structure. However, in their view, the decisive factor for the occurrence of various species is the height above sea level of the investigation area (cf. also Detzel 1998; Ingrisch and Köhler 1998). This is in line with the results presented here. In their investigations, however, the size of grazed areas (0.9–15.4 ha) was also a factor which positively impacted on the species density. This finding cannot be confirmed here (see below). In an analysis of a single species (the wart-biter, *Decticus verrucivorus*) in southern Norway, Hjermann and Ims (1996) showed that the occurrence probability of this species is greater for larger and less isolated habitats than for smaller and isolated areas. Admittedly, 90% of the investigated areas were under 0.1 ha in size and the largest was under 1 ha. Kindvall (1996) sees the significance of habitat size (between 0.1 and several dozen ha) for *Metrioptera bicolor* (long-horned cricket) somewhat differently. With increasing area size, he determined a significantly larger population. The determined habitat diversity was therefore independent of the area size.

For the butterflies, locational differences (exposure, different investigation areas, height above sea level) have a greater level of importance. Butterflies react more strongly to their geographical environment than to the affecting use parameters on the individual pastures. A low grazing impact in the form of the current land use (before, during or after pasturing) could be proven for some species. Among other things, butterfly imagos are characterized through their high mobility and their often complex habitat requirements. The variance in butterfly communities at larger agricultural levels, however, is shown in the reaction to the different location parameters. The on average higher species numbers for butterflies on the Thuringian pastures can be well explained through the lower altitude and the location, which in places benefited from a very warm exposure (south-west to south-east).

Among the parameters which affect landscape qualities, the significance of flowering plants (qualitively and quantatively) is a known factor in the occurrence of nectar-feeding species (cf. Erhardt 1985a; Oppermann 1987; Settele and Geissler 1989; Wettstein and Schmid 1999), and this could also be confirmed in the investigation presented here. A higher habitat diversity can result in a higher plant species diversity, but can also lead to a significant temporal extension of nutritional resources, for example, in the case of edge species. In turn, this has positive impacts on the diversity of butterfly communities (Kratochwil 1983; Kremen 1992).

In summary, the following can be stated:

- The size of the area and the form of grazing (continuous or rotation grazing) are, according to the analyses carried out here, not the decisive factors which determine the variance in species composition, and therefore also in species variety, of grasshoppers and butterflies on the investigated pastures. Even in areas of five hectares, species-rich communities could become established in a larger system of rotation grazing with reduced application of chemicals and machinery.

- Grazing has an impact, particularly for grasshoppers, through the effects of cattle eating the vegetation and therefore affecting vegetation height and cover.
- The occurrence of habitat types which are typical for undergrazed and only moderately managed pastures (bushy areas, grazing residues), in other grassland types are, however, absent, and dry, calcareous grasslands are of very great significance for the species diversity and the spatial use of the taxa investigated here in similar geographical environmental conditions.

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6.6
The Effects of Large-Scale Grazing on Spatial Structure and Grasshopper Fauna with the Example of Community Pastures in the South Black Forest

Stefan Kostrzewa

6.6.1
Introduction

Livestock grazing has an impact on the fauna of pasturelands. There are direct impacts in the form of injury or loss of animals, as is proved by the example of grasshoppers (Dolek 1994; Fartmann 1997; Fricke and von Nordheim 1992). In addition, there are also more serious, long-term indirect impacts from grazing on the habitats of such species (Ledergerber et al. 1997). These indirect grazing impacts arise from anthropogenically controlled grazing, which affects the spatial-temporal structures of habitats. The changes to the vegetation structure brought about through grazing signify spatial-temporal variations in the habitat mosaic, which in turn influence the distribution and variety of species. In grazing systems, therefore, there is a causal chain of effects: 'grazing management/location → grazing pattern → pattern of area and veg. struc. → distribution pattern for grasshoppers'.

Although individual aspects of the effects of grazing on grasshopper distribution have been thoroughly investigated (e.g., Fartmann and Mattes 1997; Fricke and von Nordheim 1992; Kiechle 1995; Müller 1998; van Wingerden et al. 1991), there is as yet no complete analysis of the causal chain referred to. Investigations of individual parts of the chain of effects give consideration to a variable number of qualities affecting spatial and vegetation structures (e.g., Kruess and Tscharntke 2002; Wettstein and Schmid 1999), apart from location factors and the general, that is, average grazing intensity. The selection of these variables is often oriented to the efforts involved in the survey, leaving largely unconsidered the controlling of the grazing pattern and the area-specific impacts of the grazing pattern on vegetation.

The large-scale community pastures which still exist today in the South Black Forest on about 10 000 ha of land are suitable for an investigation into mesoscale grazing impacts on organisms because of their large parcels of comparable land use. In addition, these large-scale (young cattle) common grazing lands are laid out in an exemplary pattern (Luick 1996), in the sense of a model of 'semi-open pasture landscape' (Conradi and Plachter 2001), so the analysis of their patterns of biodiversity is of particular interest for the organization of future grazing systems.

6.6.2
Methodology

In the South Black Forest, the behavior of cattle and their effects on the shaping of pasturelands were investigated at the mid scale, using the example of the Praeger Glacier Valley, about 30 km south-east of Freiburg in Breisgau (see Chap. 3). The biotic impacts were analyzed by means of the relatively well-known (with respect to their habitat requirements) grasshoppers. Eight different (young cattle) common pastures

(78 ha) of a paddock rotation system which was stocked with 66 animals in 2002 (0.5 LSU ha^{-1}) were investigated. Data on grazing was collected by means of opposite slope photography during the whole vegetation periods in 2000 and 2002 (see Sect. 4.4 for a detailed description). The focus was on the medium-scale mapping of the impact processes on relatively large areas. The survey methods had to be adapted to this objective.

The characteristics of the spatial and vegetation structures of the pastures and the grasshopper populations were recorded in three mapping runs: May 23 to June 5, 2002, July 2 to July 15, 2002 and August 14 to August 21, 2002. Site surveys took place on relatively windless, dry, mainly sunny days with a minimum temperature of 15 °C, in 50 × 50 m grid squares consisting of 391 grid cells. Each of the grid cells was walked crossed along a meandering 5 m wide transect line of at least 50 m long for ten minutes. To enable a better orientation across the (virtual) grid in the absence of conspicuous elements such as rocks, trees or larger bush formations, wooden posts were used. During the work on site, temporal and spatial overlapping of the investigation with the behavioral and spatial use patterns of the cattle was avoided (opposite slope photography) so as not to adversely affect the grazing behavior of the cattle.

In order to keep the amount of work on site to a practical level, the characteristics of the spatial and vegetation structures were recorded using estimate scales, partly in a metric scale but mainly in a five-stage ordinal scale. In this five-stage scale, the following scheme for the characterization of all parameters was used: 1 = very few/absent; 2 = few/low; 3 = medium; 4 = frequent/many; 5 = very frequent/very many.

This self-explanatory recording scale needs further explanation in only a few cases. The determined 'diversity' of the spatial structure is divided into a vertical and a horizontal component. The vertical component *height diversity vegetation* gives the variety of height layers of the vegetation (growths of equal height have the lowest *height diversity vegetation*). The *horizontal structure diversity* does not arise through the average proportions or characteristics of open land, vegetation cover and density, trampling and microrelief, but through the variety of their gradations and distribution over the

Table 6.35.
Vegetation types determined for young cattle pastures in the Praeg Glacier Valley

Vegetation type
Drinking troughs
Wet areas/flowing water
Cattle track/path
Bushes
Compact dwarf shrubs
Moderately compact dwarf shrubs
Patchy dwarf shrubs
Calcareous, patchy grassland
Calcareous grassland
Calcareous, fresh grassland
Mesophilic grassland (grass rich)
Mesophilic grassland (herb rich)
Rich grassland
Laegerflur
Wood/solitary tree

grid cells. For all parameters recorded over the site, the median of the three mappings is used in each case. In addition, the *vegetation type* was determined in the middle of June through separate inspections in which homogenous vegetation areas were divided into 15 different types (Table 6.35). The presence/absence of these 15 *vegetation types* in each grid cell was therefore available as a categorical variable.

Another part of the area characteristics of grid cells was determined using a digital site model (DGM30) in Arcview 3.2 (Table 6.36). The *relative height* gives information about height above sea level inside a paddock. With respect to the application of *fertilizer* within grid cells, the grazing manager/farmer was questioned so that detailed

Table 6.36. Determined characteristics of the spatial and vegetation structure

Parameter	Source	Scale
Proportion open ground	Site survey	Metric, cover proportion (%)
Area resistance vegetation <10 cm	Site survey	Ordinal, estimate classes (1–5)
Ground moisture	Site survey	Ordinal, estimate classes (1)
Biomass	Site survey	Ordinal, estimate classes (1)
Bushes	Site survey	Ordinal, estimate classes (1)
Dwarf shrub proportion	Site survey	Metric, cover proportion (%)
Herbaceous proportion	Site survey	Metric, cover proportion (%)
Plant species numbers	Site survey	Ordinal, estimate classes (1–5)
Vegetation height	Site survey	Metric (cm)
Horizontal structure diversity	Site survey	Ordinal, estimate classes (1)
Height diversity vegetation	Site survey	Ordinal, estimate classes (1)
Grazing by livestock	Site survey	Ordinal, estimate classes (1)
Trampling by grazing animals	Site survey	Ordinal, estimate classes (1)
Microrelief (= old trampling)	Site survey	Ordinal, estimate classes (1)
Vegetation type	Site survey	Categorical, 15 types
Height above sea level	GIS + Site survey	Metric (m)
Relative height (within paddock)	GIS + Site survey	Ordinal, estimate classes (1–5)
Slope angle	GIS + Site survey	Metric (°)
Southern exposure	GIS + Site survey	Classens1-6, ordinal
Distance cattle camp	GIS + Site survey	Metric (m)
Distance water trough	GIS + Site survey	Metric (m)
Neighborhood effects	GIS + Rook's case	Average of 4 neighbor cells
Fertilising	Farmers	Nominal (yes, no, part fertilized)
Grassland yield index	Soil map	Metric, number

information could be marked on aerial photograph prints. As there were no detailed soil maps covering the investigation area, grassland yield indexes from the ground survey 1982 (1:2000) were used.

Grasshoppers were recorded in the transect crossings using a combination method of listening and netting (25 double sweeps per grid cell) so that it was possible to record both species difficult to catch, that is, in awkward habitats (e.g., bushes) and also quiet, inconspicuously stridulating species. The species were determined in accordance with Bellmann (1993). Because of their different phenology, species of the family Tetrigidae were not included. The adults determined for each grid cell during the three site visits were totaled.

Regression models were used with SPSS 10.5 as *generalized linear models* (GLM) in a stepwise-backwards procedure.

6.6.3
Results

Grazing Pattern

The pattern of spatial use realized by the cattle, as the first link in the above-mentioned chain of effects, can best be represented in 50 × 50 m grids as *use intensity* for each grid cell. The *use intensity* is the relationship of the actual observed number of cattle per grid cell to their hypothetical number for an equal distribution over the grid. Therefore, the *use density* gives the density of visits by the cattle to sections of the

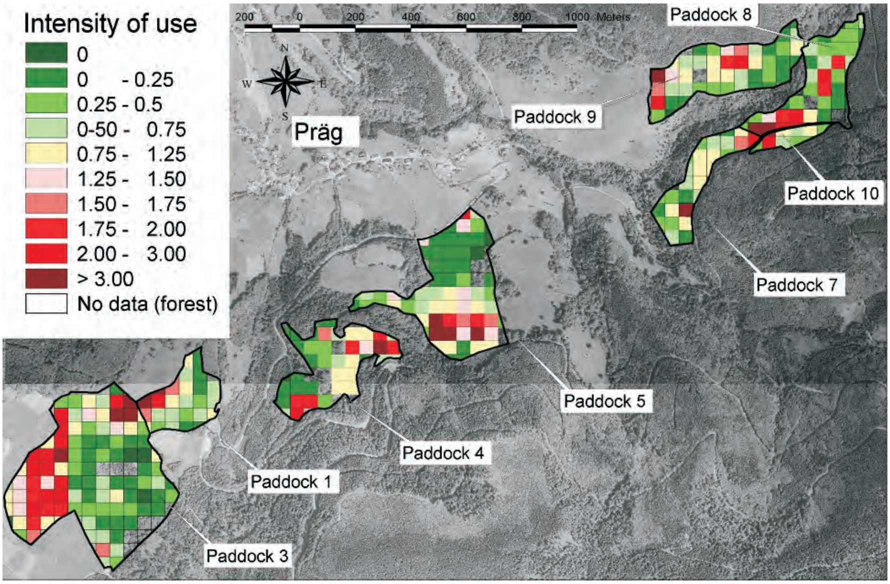


Fig. 6.39. *Use intensities* for 2002 on 8 young cattle paddocks in the Praeg Glacier Valley. The intensity values relate to a hypothetical equal distribution of the 20118 visit points of the cattle in 50 × 50 m grid squares for each paddock. In thickly wooded areas, there is no methodologically determined data (opposite slope photography) (transparent). $N = 391$ grid cells

pasture (but not grazing – this is recorded in grazing proportion, see below). Area-adjusted *use intensities* with values >1 (red in Fig. 6.39) show increased use frequencies against the hypothetical equal distribution. Those with values <1 (green in Fig. 6.39) show a reduced use intensity.

The pattern of spatial use for young cattle is extremely heterogeneous. On the eight paddocks of the Praeg Glacier Valley which were investigated, 71.7% of the grid cells indicate a reduced use frequency (*use intensity* <1). Against this, 28.3% of the grid cells, mainly resting and camp places, were subject to an increased use frequency (*use intensity* >1). The average value of the *use intensity* determined by calculation amounted to 1, the median, however, was in comparison 0.57, the lower quartile was 0.28 and the upper quartile 1.21. In addition, there is a large aggregation of *use intensity* in the grids, as is proved by the following autocorrelations: Moran's $I = 0.235$; $Z = 4.95$; $p < 0.01$; as well as Geray's $C = 0.88$; $Z = 1.97$; $p < 0.05$. Intensively used grid cells are found in neighborhoods of likewise intensively used cells, while in contrast, lightly used cells are grouped together.

The *use intensity* for the grid cells varied according to their locational features and the different anthropogenic controlling influences. The *use intensity* for the cattle rose, for example, with increasing *relative height* within a paddock (not to be confused with absolute height above sea level: $R_s = 0.356$; $p < 0.001$). In addition, the *use intensity* correlated positively with grassland index ($R_s = 0.368$; $p < 0.001$), the (chalk) fertilising ($R_s = 0.584$; $p < 0.001$) and the plant biomass ($R_s = 0.320$; $p < 0.001$). Distantly located cattle camps ($R_s = 0.450$; $p < 0.001$), bushy areas ($R_s = -0.369$; $p < 0.001$), dwarf-shrub-rich areas ($R_s = -0.324$; $p < 0.001$) and grid cells with steep slopes ($R_s = -0.176$; $p < 0.01$) were used significantly less by the cattle (Table 6.37). In contrast, the distance of the grid cell to the drinking troughs and their exposure did not play a role in *use intensity*. Additionally, the *use intensity* of a grid cell was linked to the *use intensity* of the spatial neighbors ($R_s = 0.688$; $p < 0.001$).

Table 6.37.
Correlations of *use intensities* with features of the grid cells. Regression coefficients according to Spearman (R_s) are marked according to significance level (p). Vegetation types are not shown. $N = 391$ grid cells

Variable	Scale	R_s	p
Relative height	Ordinal	0.356^c	<0.001
Slope angle	Interval	-0.176^b	<0.01
South exposure	Ordinal	0.000	0.994
Moisture	Ordinal	-0.113^a	<0.05
Distance cattle camp	Interval	-0.450^c	<0.001
Distance drinking trough	Interval	−0.022	0.683
Grassland index	Interval	0.368^c	<0.001
Fertilising	Ordinal	0.584^c	<0.001
Biomass	Ordinal	0.320^c	<0.001
Bush growth	Ordinal	-0.369^c	<0.001
Dwarf shrub proportion	Ordinal	-0.324^c	<0.001
Herbaceous proportion	Ordinal	0.313^c	<0.001
Neighborhood effect	Interval	0.688^c	<0.001

Table 6.38. Regression Model (GLM) for the impact of area features on the *use intensity*. Data given: direction of the impact (±), value of the *F*-statistic and parameter estimator *F* in each case with significance and a partial Eta-Square (η^2), which reflects the given variance proportion of each impact variable. Gaps in the *F*-statistics are because of categorical nature of the variables *vegetation type*. Explanatory variables: 14. *Use intensity* root transformed. $R^2 = 0.598$; Corr. $R^2 = 0.582$. $N = 391$ grid cells

Explanatory variables	±	*F*	*p* (*F*)	*T*	*p* (*T*)	Partial η^2
Vegetation type	+	10.90	<0.001	–	–	0.275
Lagerflur	+	–	–	9.82	<0.001	0.218
Rich grassland	+	–	–	7.06	<0.001	0.126
Calcareous grassland	+	–	–	4.69	<0.001	0.060
Mesophilic grassland (grass rich)	+	–	–	2.79	<0.05	0.022
Mesophilic grassland (herb rich)	+	–	–	2.61	<0.05	0.019
Neighborhood effect	+	47.42	<0.001	6.89	<0.001	0.121
Fertilizing	+	10.73	<0.01	3.28	<0.01	0.030
Relative height	+	5.55	<0.05	2.35	<0.05	0.016

The Regression Model (GLM) reduced the number of relevant impact factors affecting *use intensity* by a model class of $R^2 \sim 0.6$ to four. Accordingly, the largest impact on the distribution of *use intensity* in the grid square was caused by the vegetation type. Here, the vegetation types *Laegerflur (eutrophic vegetation due to cattle droppings*), *rich grassland* and *calcareous grassland* are mainly responsible for high *use intensity*, which can be taken from the high proportion of representation in the total variability (partial Eta-square, η^2) (Table 6.38). *Mesophilic grassland* has a comparably weak effect on *use intensity* and the ten remaining vegetation types have no significant impact. The second largest impact on the distribution of *use intensity* in the grid square is the spatial neighborhood effects, followed by the factors *fertilising* and *relative height.* The impacts of both of these, controlled through anthropogenic grazing management features, (managed through selection and demarcation of the area) is, however, relatively low in comparison to locational factors (or neighborhood effects). The Regression Model implies, then, that high *use intensities* by cattle would be expected or predicted, above all on particular, very nutrient-rich or calcareous *vegetation types* in likewise intensively used spatial neighborhoods. Furthermore, there are high *use intensities*, that is, *visit densities*, where there are high fertilising effects and on the upper slopes of a pastureland.

The model is capable of correctly forecasting a proportion of 51.9% (*g*-value in accordance with Agterberg 1984) of the observed use intensities.

For the validation, such models are best transferred in space and time to other areas or datasets in accordance with Guisan and Zimmermann (2000). Therefore, the model is transferred to *use intensities* on other pastures (paddocks 2, 6) which have already been examined in the year 2000. For this validation, the *use intensities* (Fig. 6.40, below) forecast by the model agree to 85.2% (*g*-value) with the actual observations for *use intensities* (Fig. 6.40, above).

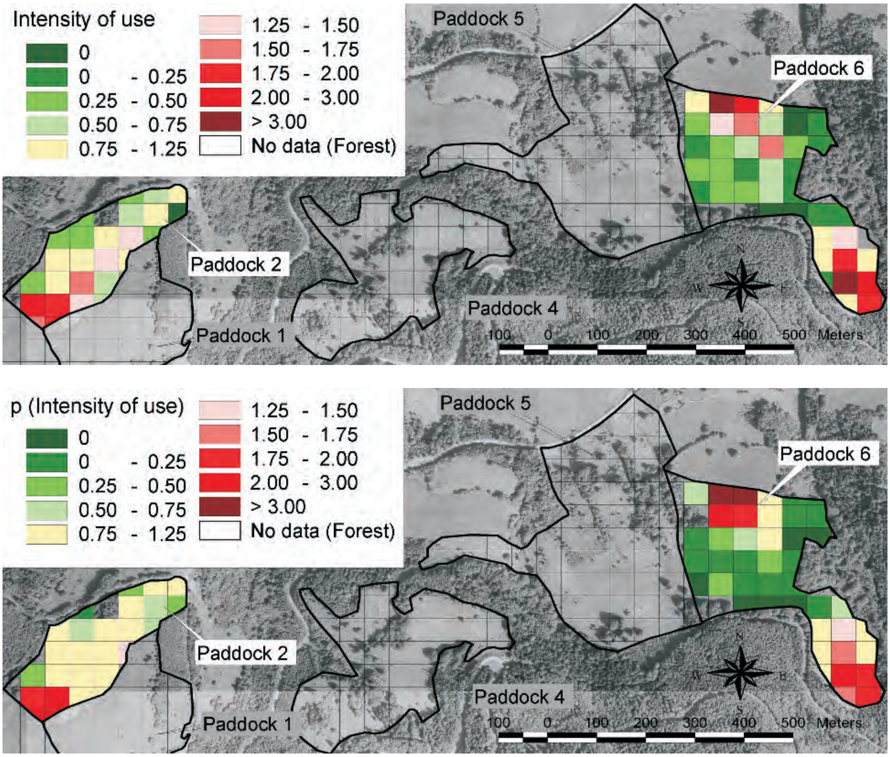


Fig. 6.40. Model validation: In 2000 on paddocks 2 and 6, actual observations of *use intensity* (above) and the *use intensities* forecast with the data from the 2002 developed model (below). $N = 77$ grid cells

Patterns of Space and Vegetation Structures

The features of the space and vegetation structures (second link in the chain) are in part influenced by the grazing pattern of the cattle. However, this grazing pattern does not only consist of the general *use intensity* (all visits) but also is divided into the different aspects of spatial use, according to the behavior types which the cattle realized. Proportions of the behavior types *resting*, *grazing* and *forward motion* can be assigned to each grid cell.

The 'spatial structure in narrower sense' (proportion of open ground, height diversity vegetation, horizontal structure diversity, microrelief, spatial resistance up to 10 cm and plant species numbers) is not adversely affected by the current use intensity by the cattle, that is, the mere visit alone. The type of spatial use, however, has a similarly strong effect on these features of spatial structure. For a high grazing use type, the spatial structure is maximally affected. For example, with intensive grazing, there is the highest height diversity ($R_s = 0.114$; $p < 0.05$). In contrast, a frequent use of the grid cell for resting reduces the height diversity of the vegetation ($R_s = -0.121$; $p < 0.05$) and the horizontal structure diversity, the proportion of open ground and plant species numbers (Table 6.39). All types of spatial use are correlated negatively with bush growth and dwarf shrub proportion of

Table 6.39. Correlations for individual variables of spatial and vegetation structure with grazing parameters (*use intensity*, *resting*, *grazing*, *forward motion*). Spearman's Correlation coefficients (R_s) are marked: $^a\ p < 0.05$; $^b\ p < 0.01$, $^c\ p < 0.001$; $N = 391$ grid cells

Vegetation structure	Use intensity		Rest proportion		Grazing proportion		Forward motion proportion	
	R_S	p	R_S	p	R_S	p	R_S	p
Open ground proportion	–0.066	0.211	–0.180	<0.01	0.137	<0.01	0.162	<0.01
Height diversity vegetation	0.020	0.700	–0.121	<0.05	0.114	<0.05	0.100	0.059
Horizont. structure diversity	–0.049	0.357	–0.115	<0.05	0.142	<0.01	0.059	0.262
Plant species number	0.027	0.615	–0.131	<0.05	0.116	<0.05	0.116	<0.05
Microrelief	0.010	0.848	–0.077	0.121	0.079	0.134	0.021	0.689
Spatial resistance <10 cm	0.056	0.290	0.133	< 0.05	–0.091	0.086	–0.121	<0.05
Bush growth	–0.396	<0.001	–0.329	<0.001	–0.245	<0.001	–0.090	0.087
Dwarf shrub proportion	–0.324	<0.001	–0.260	<0.001	–0.252	<0.001	–0.026	0.624
Vegetation height	0.119	<0.05	0.216	<0.001	–0.054	0.319	–0.068	0.209
Grazing	0.301	<0.001	0.256	<0.001	0.253	<0.001	–0.040	0.450
Trampling	0.069	0.188	–0.019	0.724	0.052	0.322	0.137	<0.01

the grid cells. For high use intensity, the values for bush growth and dwarf shrub proportion ($R_s = -0.396$; $p < 0.001$ and $R_s = -0.324$; $p < 0.001$ respectively) are just as low as for a frequent use for grazing or resting (Table 6.39). In resting areas, the vegetation is particularly high. Grazing marks are present at almost all spatial use categories but trampling marks are present only with a high value for forward motion.

The spatial structure of the pastures is determined not only through the grazing and spatial use patterns of the cattle, but also through the location and the anthropogenic controlling influences. As regression analyses show, both *height diversity of vegetation* and *horizontal structure diversity* are more affected by the location than by the grazing (Table 6.40). In particular, southern exposures have greater effects for both of these aspects of structure, as is shown in the comparable highest given variability proportions (Table 6.40). In addition, the *height diversity of the vegetation* is determined to a small extent by soil moisture, while the *horizontal structure diversity* is subject to the influences of *slope angle* and *fertilising*. As grazing influences on both aspects of structure, *resting* has a negative effect and *grazing* a positive one.

Distribution Pattern of Grasshoppers

On the eight investigated common pastures, 23 grasshopper species were determined. Among the almost eight thousand adult grasshopper individuals, the most frequent was *Chorthippus parallelus* with 28% occurring with a consistency of ~96% on almost all grid cells (Fig. 6.41). The second most frequent of all the grasshopper finds was *Omocestus viridulus* with 14.9%, followed by *Metrioptera roeselii* (12.5%) and

Table 6.40. Regression analysis (GLM) of *height diversity vegetation* ($R^2 = 0.291$) and *horizontal structure diversity* ($R^2 = 0.337$) influenced by location and grazing. Only the significant influences are shown, given from the partial Eta-square η^2 (= explained proportion of total variability). Signs (–) are used to indicate negative impact variables. Significances are marked according to significance level (^{a} <0.05, ^{b} <0.01, ^{c} <0.001). Explanatory variables = 16. $N = 391$ grid squares

Variable	Slope angle	South exposure	Fertilizing	Moisture	Resting	Grazing
Height diversity vegetation	–	0.100^{c}	–	–0.011^{a}	–0.011^{a}	0.015^{a}
Horizontal structure diversity	0.021^{b}	0.276^{c}	–0.035^{c}	–	–0.012^{a}	0.019^{b}

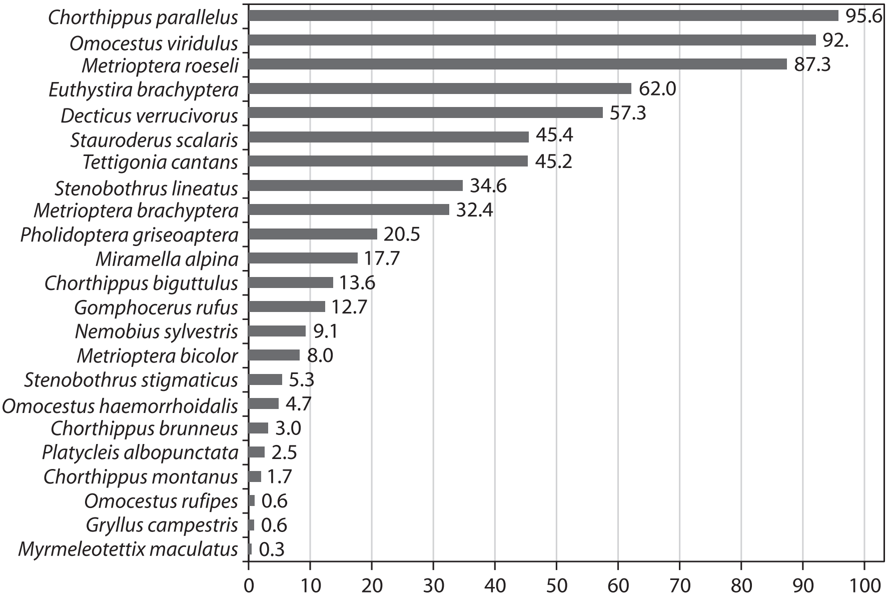


Fig. 6.41. Consistency of grasshoppers (%) for all grid cells on common pastures. $N = 391$ grid cell

Euthystira brachyptera (11.1%), which achieved consistencies of 92%, 87% and 62% respectively in the grid cells. In fifth and sixth places were the species *Decticus verrucivorus* and *Stauroderus scalaris*, which are threatened in the region. Twelve of the twenty-three grasshopper species occur very rarely, with proportions <2%, and were found in 0.3–17.7% of the grid cells (Fig. 6.41).

In a grid cell, an average of 6.0 ±2.9, maximum 14, minimum 0, grasshopper species was found. Because of the slightly increased proportion of grid cells without any grasshoppers, the species numbers are not normally distributed over the grid cells.

The spatial distribution pattern of the grasshopper species numbers over the grid square of the Praeg Glacier Valley is not random or regular, but shows to a greater extent, a degree of aggregation (Fig. 6.42). This spatial aggregation of the grasshopper abundance is statistically proved by the autocorrelations of Moran I (0.446; $p < 0.01$) and Geray's C (0.546; $p < 0.01$). Grid squares with a high species number are therefore

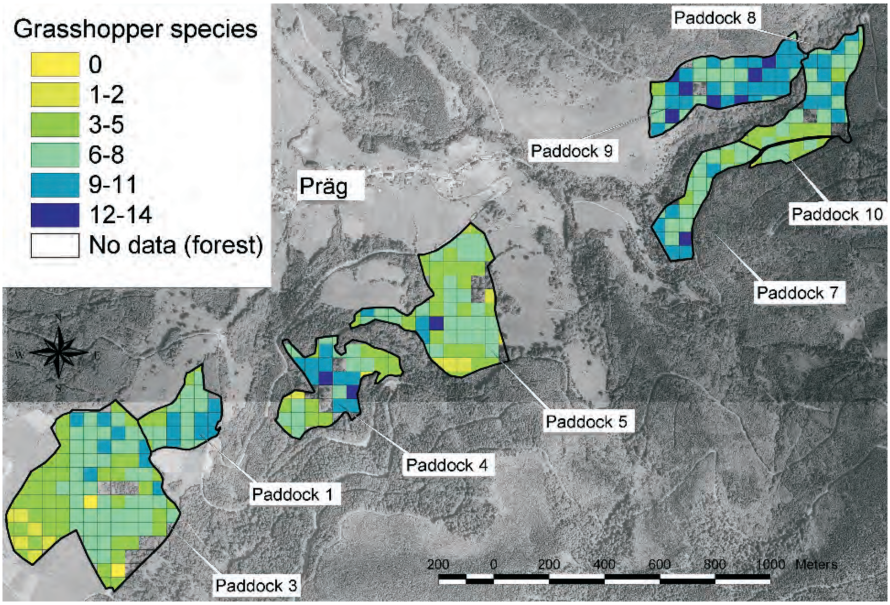


Fig. 6.42. Species numbers for grasshoppers in 50 × 50-m grid squares on the young cattle pastures of the Praeger Glacier Valley. $N = 391$ grid cells

surrounded by similar cells (cf. paddock 9 in Fig. 6.42), while areas with low grasshopper abundance aggregate similarly (west of paddock 3 in Fig. 6.42).

The distribution of grasshoppers in the grid (third link in the causal chain, see Fig. 6.39) is influenced by all of the previous components: grazing pattern and its control factor, location or grazing management, spatial and vegetation structure, and also by generally active spatial neighborhood effects. As part of the grazing impacts, the behavior types *grazing* and *forward motion* have a positive effect on grasshopper abundance in the grid cells ($R_s = 0.323$; $p < 0.001$) and ($R_s = 0.181$; $p < 0.001$) respectively. There are clear locational gradients with respect to grasshopper abundance: *height* (negative), *southern exposure* (positive), *grassland index* (negative) and somewhat weaker for *slope angle* (positive) and *soil moisture* (negative) (Table 6.41).

In addition, the number of grasshoppers in a grid cell is very positively correlated with a number of the features of spatial and vegetation structure, particularly with *open ground proportion*, *height diversity vegetation*, *horizontal structure diversity*, *microrelief*. All structural features which indicate density or height of vegetation growths, such as *spatial resistance <10 cm*, biomass, vegetation height, *herbaceous proportion* negatively affect the abundance of grasshoppers. Additionally, high proportions of *bush growth* and *dwarf shrubs* support the species abundance of grasshoppers in the grid square significantly. The grazing effects of cattle have a negative effect on grasshopper numbers, whereas trampling by cattle had no effect. The strongest correlation ($R_s = 0.600$; $p < 0.001$) was for the spatial neighborhood effects of the grasshopper abundance, that is, grid cells in species-rich surroundings (average value of four neighboring grid cells) are similarly species rich.

Table 6.41.
Correlations for species numbers of grasshoppers with features of the young cattle pastures. Correlation coefficients in accordance with Spearman (R_S) are marked for significance (p) with the following: ^{a} <0.05, ^{b} <0.01, ^{c} <0.001. N = 391 grid cells

Impact variable	R_S	p
Use intensity	–0.087	0.097
Resting proportion	–0.057	0.259
Grazing proportion	0.323^c	<0.001
Forward motion proportion	0.181^c	<0.001
Height above sea level	–0.334^c	<0.001
Relative height	–0.064	0.088
Slope angle	0.160^b	<0.01
Moisture	–0.196^c	<0.001
Grassland index	–0.359^c	<0.001
Southern exposure	0.440^c	<0.001
Fertilizing	–0.184^c	<0.001
Open ground proportion	0.549^c	<0.001
Height diversity vegetation	0.548^c	<0.001
Horizontal structure diversity	0.548^c	<0.001
Plant species number	0.448^c	<0.001
Microrelief	0.388^c	<0.001
Spatial resistance <10 cm	–0.408^c	<0.001
Bush growth	0.284^c	<0.001
Dwarf shrub proportion	0.223^b	<0.01
Biomass	–0.320^c	<0.001
Vegetation height	–0.287^c	<0.001
Herbaceous proportion	–0.021	0.699
Grazing	–0.233^c	<0.001
Trampling	0.023	0.666
Neighborhood effect	0.600^c	<0.001

From this number of impact factors affecting grasshopper abundance, a regression model ($R^2 = 0.56$) determines 6 relevant variables. Of primary importance for the occurrence of grasshoppers is the *horizontal structure diversity*, that is, a parameter partially determined by grazing. This finding is statistically confirmed through the comparably highest values (against other impact variables) of the partial Eta-square (η^2) and of T (Table 6.42). The second largest influence on the distribution of grasshopper species is from spatial neighborhood effects. The third and fourth most important influencing variables on grasshopper abundance are the locational gradients height above sea level and slope angle. With decreasing priority within the model for grasshopper species numbers are the influencing variables *height diversity vegetation* and

Table 6.42. Regression model (GLM) of the impact factors on grasshopper abundance. Information given: direction of impact (±), value of F-statistic and parameter estimate F with in each case significance and a partial Eta-square (η^2), which reflects the given variance proportion for each impact variable. Explanatory variables: 28. $R^2 = 0.565$; Corr. $R^2 = 0.558$. $N = 391$ grid cells

Explanatory variables	±	F	p (F)	T	p (T)	Partial η^2
Horizontal structure diversity	+	2.70	<0.001	5.8	<0.01	0.79
Neighborhood effect	+	28.92	<0.001	5.8	<0.01	0.77
Height above sea level	–	15.91	<0.001	–3.9	<0.01	0.44
Slope angle	+	14.68	<0.001	3.3	<0.01	0.40
Height diversity vegetation	+	12.45	<0.001	3.3	<0.01	0.34
Southern exposure	+	6.71	<0.1	2.9	<0.1	0.19

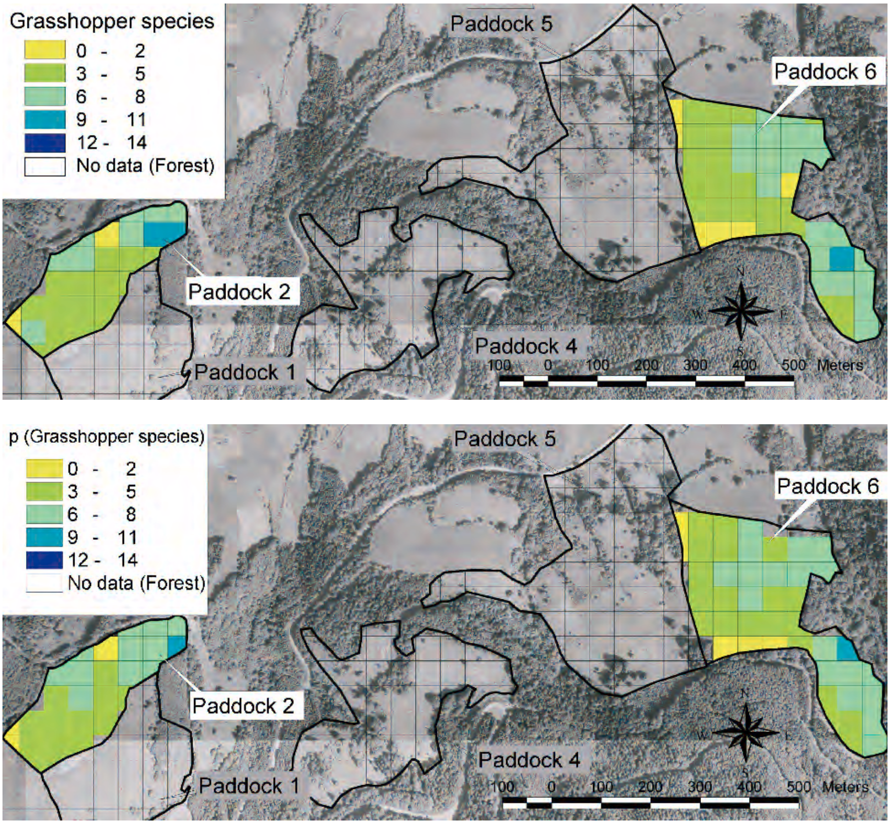
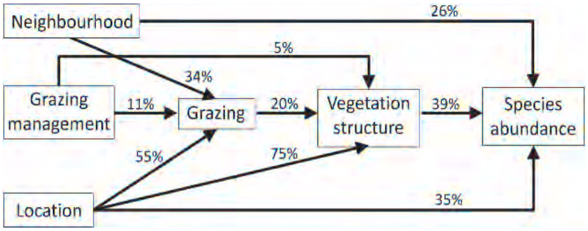


Fig. 6.43. Model validation on the paddocks 2 and 6 in the year 2000, actually observed grasshopper species numbers (above) and the grasshopper species numbers forecast through the model (based on data from 2002) (below). $N = 77$ grid cells

Fig. 6.44.
Impact factors in the causal chain 'humans/location → cattle → structure → grasshopper species', shown as a relative proportion of the explained variance in the regression model. The parameters were arranged in groups and their partial η^2 totaled. $N = 391$; grid squares measure 50 × 50 m



southern exposure of the grid cells. All other variables did not contribute to any meaningful extent to the explanation of the distribution of grasshopper species in the grid squares, despite partially significant correlations. The listed regression model is capable of forecasting correctly a proportion of 58.7% (*g*-value) of the observed grasshopper species numbers. In a transfer/validation of the model to other test areas (paddocks 2 and 6), 74.1% (*g*-value) of the forecast species numbers agree with the actual observed number of grasshopper species (Fig. 6.43).

There is therefore an interaction between (grazing determined) structural features (*horizontal structure diversity*, *height diversity vegetation*), locational factors (*height*, *slope angle*, *exposure*) and neighborhood effects which is responsible for the distribution and occurrence of grasshopper species on the community pastures. The (vegetation) structure features have a key role here, as in total, they exert the largest impact on grasshopper abundance, coming before locational and neighborhood effects, as is made clear in Fig. 6.44. by means of the explanatory variance proportions (total of partial η^2, cf. Table 6.37, 6.39 and 6.41).

As the three model levels arranged in series indicate, the vegetation structure is controlled mainly through locational features and only to 20% through the grazing pattern. The grazing management has hardly a direct effect on the vegetation structure (5%), but rather impacts indirectly via the grazing control (Fig. 6.43). The grazing pattern is above all controlled by locational and again, spatial neighborhood effects, that is, the aggregated (herd) behavior of the cattle (Fig. 6.44). It is also noticeable that grazing has no direct impact on the distribution of species abundance for grasshoppers. Its effects on grasshopper distribution occur through the vegetation structure, that is, finally through the whole causal chain. The path 'grazing management → grazing → vegetation structure → grasshopper species' represents the framework for anthropogenic control of the species diversity. As all other factors are more or less unchangeable, the grazing management therefore has a relatively small but, because of this control possibility, significant role.

6.6.4
Discussion

Grazing Pattern

The spatially highly-aggregated distribution of the grazing animals found here, that is, the very heterogeneous pattern of spatial use, has also been described by several other authors. (Day and Detling 1990; Fischer 2000; Fryxell 1991; Pratt et al. 1986; Putman et al. 1991; Senft et al. 1985). Putman et al. (1991) also used grid squares over large pastures (90–167 ha) to show several centers of use intensity by cattle, as did Schalitz and Beckmann (1998). According to Putman et al. (1991), this pattern of use is dependent on the size of the area and the number of livestock, as is proved by the frequenting of 25% of the large pastures referred to (1.2 LSU ha^{-1}) by the cattle compared to the use of the whole area of a 'normal' modern pasture (1.7 LSU ha^{-1}).

The grazing pattern of cattle is controlled through the dispersion of particular plant species (Putman et al. 1991) and vegetation types (Pratt et al. 1986; Putman et al. 1987), as the findings from the South Black Forest also show. According to other investigations, the vegetation height is of critical importance for the pattern of spatial use realized by cattle (Distel et al. 1995; Putman et al. 1991). A quantification of the vegetation control from the grazing pattern is made difficult by the existing feedback mechanisms between grazing animals and vegetation (grazing, defecation, nutrient cycle) (e.g., Conradi and Plachter 2001; Day and Detling 1990; Putman et al. 1987).

The pattern of grazing can also be controlled by the availability of water. In this case, local use intensities would be highest in the vicinity of water sources (Hart et al. 1993; Senft et al. 1983, 1985). Also, the optimal grazing area would lie within a radius of 0.8 km from a water source and would not exceed a maximum distance of 1.6 km (Stuth 1991). However, these studies were mainly carried out in semi-arid conditions, in which the primary control of spatial use patterns through water availability is plausible. Results from partially dry areas such as the Swedish island of Oeland underline this finding. On Oeland, admittedly, significantly greater distances are also accepted (Sect. 6.3). On the pastures of the Southern Black Forest, which are characterized by a narrowly interlinked network of natural and artificial water sources (in part established with considerable effort), the distance to water sources is not a significant factor for the grazing pattern.

Additionally, the findings from the Praeg Glacier Valley deviate from Hart et al. (1993), who found no correlation for use intensity with slope angle and height. The absolute height above sea level does not have any great relevance as an influencing factor within a grazing system divided into paddocks, as in the South Black Forest, because of the generally low differences in height. Of much more significance there is the *relative height* inside a paddock, as the cattle prefer high-lying areas for reasons of energy expenditure and avoid sections of slope further down because of the steep slope.

Models for spatial use patterns have hitherto referred mainly to *patch selection*, that is, the nutritional strategies and food preferences of grazing animals (see overview in Laca and Demment 1996). Most of these have focused directly on spatial density distributions of grazing animals, which does not always explain this satisfactorily (Milne and Sibbald 1998). The authors derive from this the requirement for models which consider the spatial distribution of plant species and vegetation structures and can create forecasts for the spatial use pattern of grazing animals and their effects on the environment. The regression model described here meets the requirements of a comparably high model and forecast performance (see, for example, Senft et al. 1983, 1985).

Anthropogenic grazing management offers an effective opportunity to control the grazing pattern. Through selection of area and demarcation, locational factors such as *relative height* or slope angle of the pasture can be specifically changed. In addition, anthropogenic fertilizer application, practiced in the South Black Forest as 'lime maintenance fertilising', influences the grazing pattern significantly, particularly because it increases existing aggregational tendencies. Another factor is the position of drinking troughs, according to Schalitz and Beckmann (1998). With these 'position adjustors', the pattern of spatial use of the cattle can be 're-set' in order to maximize the variety of vegetation structure and also the variety of grasshopper species.

Spatial and Vegetation Structure

Grazing effects on the area mainly consist of the components grazing vegetation, trampling, spreading of excrement and cattle camps, as well as the diaspore distribution (Kapfer 1995), which has short-term effects on species composition (Day and Detling 1990) via injury or destruction of individuals and long-term effects via the selection and distribution of nutrients, and therefore also on the spatial structure (Sala 1988).

Compared to other hoofed animals, cattle have a relatively low trampling effect (Maertens et al. 1990) and this is manifested mainly in the form of light to heavy so-called trampling damage, which is a subject for controversial discussion (Kiechle 1995). According to Sheath and Carlson (1998), the worst trampling damage occurs on moderate slopes under 25°, on the cattle tracks and at cattle camps, which in the case of the South Black Forest only applies for cattle tracks, because of the high-lying, level resting places. On the other hand, trampling can be seen as a structurally-enriching element (Conradi and Plachter 2001), offering niches for plant germination, creating a warm micro-climate (Kapfer 1995), and functioning as a specific habitat for particular animal species (see, for example, Elligsen et al. 1997).

Through the impacts mentioned here, grazing has direct effects on vegetation height, anatomy, growth and life forms of plants (Dupré and Diekmann 2001). In addition, grazing affects plant variety and different impacts are possible, dependent on ecosystems and spatial scale (see Hambäck and Beckerman 2003 for overview). With respect to the cattle pastures of the South Black Forest, cattle grazing has a positive influence on plant abundance, whereas rest places or lightly used areas have fewer species. The appraisal that a considerable part of plant diversity and the accompanying structural variety come about through locational factors can also be confirmed from studies in the South Black Forest (e.g., Gough et al. 1994; Grace and Jutila 1999).

The diversity of the horizontal and vertical spatial structures arises from the sum of these grazing effects. In particular on the cattle pasture (*grazing*), there is a varied spatial structure, while unused areas or rest places are characterized by a corresponding level of structural poverty. Interestingly, positive and negative effects of *grazing* and *resting* balance themselves out at the level of 'general' use intensity. Consequently, the frequent presence or absence of grazing animals alone gives no information on the variety of horizontal and vertical structure – much more, the type of spatial use is decisive.

Distribution Pattern of Grasshoppers

The distribution of grasshoppers is clearly determined by the horizontal and vertical vegetation structure (Bölscher et al. 1995; Chambers and Samways 1998; Fricke and von Nordheim 1992) and can even be correlated with vegetation types (Fartmann 1997). However, for concrete assessments, such statements are actually too indefinite. Therefore, the investigation that is presented here took into account thirteen features of spatial structure.

According to Kruess and Tscharntke (2002), for the species numbers for grasshoppers, there is a significant negative correlation with the degree of vegetation cover, which is expressed in the South Black Forest through the positive correlation with the proportion of open ground. In contrast to this, according to findings made by van Wingerden et al. (1991), thick vegetation is necessary in the lowlands of Central Europe for species abundance of grasshoppers. However, in their investigations in heavily-stocked grazing systems with short grass swards, thick vegetation plays more of a refuge function; the significance of this is therefore dependent at least on the grazing intensity.

However, climatic and ecosystem factors also have an effect on this relationship (cf. Capinera and Sechrist 1982; Chambers and Samways 1998), in the sense that in cooler regions such as high locations in Central Europe, thick vegetation signifies an unfavorable microclimate for grasshoppers (van Wingerden et al. 1991). On the other hand, thick vegetation also offers protection, nutrition and a stable microclimate, which is why many of the grasshopper species found here need this just as they need short-grass, warmer areas (Detzel 1998).

Uneven grazing generates these structural successions and is therefore necessary for many grasshopper species (Fartmann and Mattes 1997), as is proved by the findings from the South Black Forest, which testify to the important influence of *height diversity of the vegetation* on grasshopper abundance. The factor *horizontal structure variety* is even more significant than vertical structure variety for the distribution of grasshoppers. This is proved also by Kruess and Tscharntke (2002) with positive correlations and they see the reason for this as the strongly differentiated habitat mosaic caused by the horizontal structure variety. Bölscher et al. (1995) give vertical structure, followed by microclimate and horizontal structure of the vegetation as the most important factors for the distribution of (hygrophilous-stenecious) grasshopper species.

With a resolution of 50 × 50 m for the grid squares used here, it is not the structural features per se but rather the variability in a grid cell which is of significance for the species abundance of grasshoppers. With a higher resolution, it is certain that smaller-scale features such as open land, trampling etc. would acquire more importance, while the influence of neighborhood effects (a 'mixed variable' of grid resolution and population biology) would possibly reduce in significance. Then again, structure heterogeneity itself is also a feature to which grasshoppers react, according to Kimberley and Crist (1996). The numbers in diversely structured grid cells are richer in species and individuals. Kindvall (1996) interprets this by suggesting that the risk of extinction with habitat heterogeneity is also lower on smaller areas than on larger homogenous areas.

As the correlations found here prove, other structural features of the pasture such as the extent of bush growth also positively affect the grasshopper numbers, which contradicts the findings of Köhler and Kopetz (1993). Admittedly, particularly thick and woody bush growth was not tested as no data on the grazing pattern (opposite slope photography) could be collected as an explanatory variable.

The effects of diverse abiotic location gradients on the distribution pattern of grasshoppers are quite well known. In Central Europe, the gradients for exposure, slope angle and height are particularly influential (e.g., B. Detzel 1998; Sänger 1977). According to Wettstein and Schmid (1999), the species number of grasshoppers is rather more dependent on such geographical factors, while the individual density is mainly influenced by habitat quality, that is, by structural features. Despite the existence of location gradients, they have to be discounted on the grounds of the discussed effects of spatial and vegetation structure. On the investigated medium spatial level, area size can be ruled out as a further abiotic gradient (grid cells in large pastures show no significant differences to grid cells in small paddocks). This is not particularly surprising, as the investigations in the grid squares explain rather the distribution pattern *inside* a pasture and indicate relationships to the area size only at higher spatial levels.

On the whole, the three model levels arranged in series, analogous to the chain of effects 'humans/location → cattle → structure → grasshopper species', explain the distribution of grasshoppers in the grid square very well. In addition, the relatively balanced impact proportions of location, vegetation structure and neighborhood effects reflect the known distribution causes of grasshoppers (cf. Detzel 1998). Grazing effects on the grasshopper abundance consist mainly of vegetation structure and not directly through the immediate, direct effects of grazing. The anthropogenic grazing management likewise has an indirect effect on species distribution via the control of the grazing pattern. To this extent, the findings for the meso-level confirm the existence and mode of action of the causal chain. At least with respect to the grazing pattern (first model level) and the distribution pattern of the grasshoppers (third model level), the model accuracies achieved for outdoor ecological investigations are satisfactory.

The results for the second model level (vegetation structure) are, however, not satisfactory, particularly with respect to the high locational effect and the relatively low grazing impact, which restricts the significance of the described chain of effects. The reasons for this are on the one hand, the (time efficient) data collection in estimated scales, which is certainly inadequate for some parameters. On the other hand, the selected scale of the 50 × 50 m grid squares particularly affects the measured values of the spatial structure, as relatively course 'average values' of a grid cell are always recorded. With finer resolutions, however, the meso-scale area coverage would no longer have been achievable.

The key to the distribution and variety of grasshoppers lies in the pasture management as most of the other relevant factors are relatively unchangeable. The application of fertilizers polarizes the pattern of spatial use of the cattle and brings about an increased division of the pasture into large areas of bush growth on the one hand and small areas of concentrated spatial use round the resting places on the other. A further controlling mechanism is achieved with area boundary works.

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6.7
The Significance of Cattle for the Nutrient Patterns of Large Scale Pastures

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6.7.1
Introduction

Herbivorous livestock prefer different locations within a pasture for their particular living requirements. For cattle, it is clear that the places they use for feeding and defecation are spatially separated with a high level of constancy. Investigations which have been carried out so far indicate that this pattern of behavior can have a significant effect on the distribution of nutrients over the pasture (Sect. 6.1, 6.3; Augustine 2003; Frank and Evans 1997; Haynes and Williams 1993; Hochberg 1998; Pötsch 1998; Schnyder et al. 2002; Schütz and Schnyder 1998; Spatz 2001; Tolsma et al. 1987; Turner 1998a,b; Weise et al. 1998; Zube 1996). This has consequences for the distribution and composition of vascular plant species, and therefore on the habitat spectrum of animals (Fernandez-Gimenez and Allen-Diaz 2001; Friedel 1997; Tolsma et al. 1987; Turner 1999; Turner 1998a,b). The research findings have up to now confined themselves to individual, small or medium-sized pastures. There were no systematic comparative studies based on the size of the area as a significant factor for the occurrence of the corresponding pattern of behavior.

The investigations are based on the following working hypotheses:

1. On large-scale pastures, there is a particularly distinct spatial separation between the locations for feeding and fecal excretion. The latter activity is maintained with a high degree of consistency over the medium term.
2. Nutrient removal through feeding on the one hand and fecal excretion on the other causes on large-scale pastures a heterogeneous distribution of soil nutrients. The naturally existing habitat diversity is increased through this.
3. The spectrum of plant species for preferred locations with high nutrient inputs differs significantly from other surrounding locations.

6.7.2
Methodology

For the investigations, which took place from May to September 2003, three mesoscale set stocking pastures (20–45 ha) in the Thuringia Rhoen, Germany, and one large set stocking pasture (640 ha; ‘Gynge’, near Resmö) in the southern part of the island of Oeland, Sweden, were selected. For comparison purposes, two additional rotation pastures of 5–7 ha in the Thuringian Rhoen were included (see Chap. 3).

With the measurable effects of the cattle behavior under consideration, low nutrient levels of the pastures can be expected in particular. While the set stocking pastures of the Thuringian Rhoen are classified as mesotrophic to eutrophic, the nutrient level of the Swedish area is decidedly low. It lies on a level chalk layer (Alvar) with particularly

Table 6.43. Soil characteristics of the investigated areas in the Thuringian Rhoen according to geological and soil maps (Thüringer Landesanstalt für Umwelt und Geologie 1906, 1907, Königlich Preussische Geologische Landesanstalt 1909, 1912). *SS:* Set stocking, *RP:* rotational pasture

Investigation area	Parent rock	Soil type	Stoniness
Rotenhauck SS and RP	Calcareous schist of the lower shell-lime	Loam	Very stony
Ellenbogen SS and RP	Basalt	Loam	Stony-gritty
Hemschenberg SS	Basalt or chalk of the upper shell-lime	Loamy-clay or loam	Very stony or stony-gritty

shallow karst soils (Johansson 1978; Königsson 1968). The soil characteristics of the Thuringian Rhoen are shown in Table 6.43.

An area-wide survey of the large pastures with sufficient resolution was discounted because of the dimensions and high levels of local heterogeneity. However, an area-wide survey is not absolutely necessary to answer the given questions – parallel investigations on the same pastures mean that the favored conditions for particular life manifestations are already known (Sect. 6.1–6.3). Preferred locations arise at drinking troughs, in largely shaded islands of trees and at licking stones. A clearly increased frequency of visiting by the cattle is also found at linear structures such as walls and fences. The design of the investigation exploited the known behavior of the cattle with respect to the preference for depositing excrement in the area surrounding their resting places (Behrendt et al. 2000; Ebel and Milimonka 1999). Behavior which was comparable, if shown to a lesser extent, could be expected for preferred tracks along linear structural elements. Where it was found that despite all other heterogeneity, there were constant differences between such places and their surroundings, these could only be explained by the corresponding impacts of the cattle.

In order to further assure the assumption that excrement was in fact regularly deposited around resting places, the number of cow pats at each resting place was estimated on 14 areas measuring 2 × 2 m each, in 5 categories (0, 1–3, 4–20, 20–50, >50 cow pats). This method is recommended as a way of determining the visiting density of cattle (Schalitz and Fechner 1998). There are considerable error sources attached to this (e.g., different break-down speeds dependent on moisture level) but it is suitable as a rough starting point for the task in hand. For each grid square, the grid cells with a number of cow pats >20 were analyzed using the Poisson distribution and were assigned to one of the following three distribution patterns (Southwood and Henderson 2000): regular distribution: $0 = \text{variance}/\text{average value} < 0.85$; random distribution: $\text{variance}/\text{average value} \approx 1$ (0.85 to 1.14); clustered distribution: $\text{variance}/\text{average value} > 1.14$.

In total, 187 soil samples were taken. Each soil sample consisted of 8 partial samples which lay within a 2 × 2 m square (sampling point). In the Thuringian Rhoen, the soil samples were taken from a depth of 2–12 cm (cf. Scheffer and Schachtschabel 2002) using a Pürckhauer drill rod on a total of fourteen 100-m transects. On the transects, the sample points were at 0, 10, 20, 40, 70 and 100 m distances from the assumed center of the resting place.

In addition, at all sampling points in the Thuringian Rhoen, the abundance of vascular plants was recorded in accordance with Braun-Blanquet (1964). Most of the oligotrophic and eutrophic vascular plants found in the Thuringian Rhoen were analyzed according to the correlation of the weighted abundance (Ellenberg 1979). Oligotrophic vascular plants were considered as those with nitrogen numbers 1–3 (Ellenberg et al. 2001) and for eutrophic plants, nitrogen numbers 7–9. For each sampling point in the Thuringian Rhoen, a weighted average nitrogen number was calculated by multiplying the nitrogen numbers (Ellenberg et al. 2001) with the extent of cover of the particular species. The calculated nitrogen number was tested for correlation for the 100 m transects (Bühl and Zöfel 2000).

On the set stocking pastures of Oeland, the following two location types were differentiated:

- dry to semi-dry, very shallow soil lying immediately on limestone deposits, with high chalk content and pH values <7 (Rosén and Borgegård 1999) (chalk soil)
- moderately dry to fresh, relatively deep soils with a slight acid reaction and high silicate level from Pleistocene moraines or sand deposition (Bengtsson et al. 1988) (moraine)

Because of the extreme shallowness of the limestone soils, sampling with the drill rod was not attempted. Following careful removal of the upper soil layer, the samples were taken from a depth of 0–5 cm using a shovel. The following locations were sampled:

- a semi-shaded resting place (*Pinus sylvestris*, *Juniperus* sp.) on moraines at the edge of an ephemeral lake to the west of the area (relatively moist, occasionally partly over-flowing because of previous rainfall): two cross-shaped transects 150 m and 70 m length through the center of the resting place (main transect) and its edge; in total, 23 soil samples taken at distances of 10 m (Fig. 6.45).
- the central resting place of the herd, consisting of two neighboring compact tree islands of *Pinus sylvestris*, mainly on moraines. Because of the irregular spatial structure, a sample design was selected which differentiated only between locations within woody vegetation, edges of such locations as well as distant moraine and chalk soil locations. 30 samples were taken.

The following parameters were analyzed for each soil sample in accordance with the German DIN standard (2000):

- $CaCl_2$ soluble total nitrogen (N_{total})
- $CaCl_2$ soluble ammonium (NH_4^+)
- $CaCl_2$ soluble nitrate (NO_3^-)
- CAL soluble phosphate (P_2O_5)
- CAL soluble potassium (K_2O)
- lime content ($CaCO_3$)

The differences in the nutrient contents were analyzed with *t*-tests and Tukey tests (average value comparison of more than two groups). The nutrient contents along the transects were tested for normal distribution and where necessary, transformed and tested for correlation with distance.

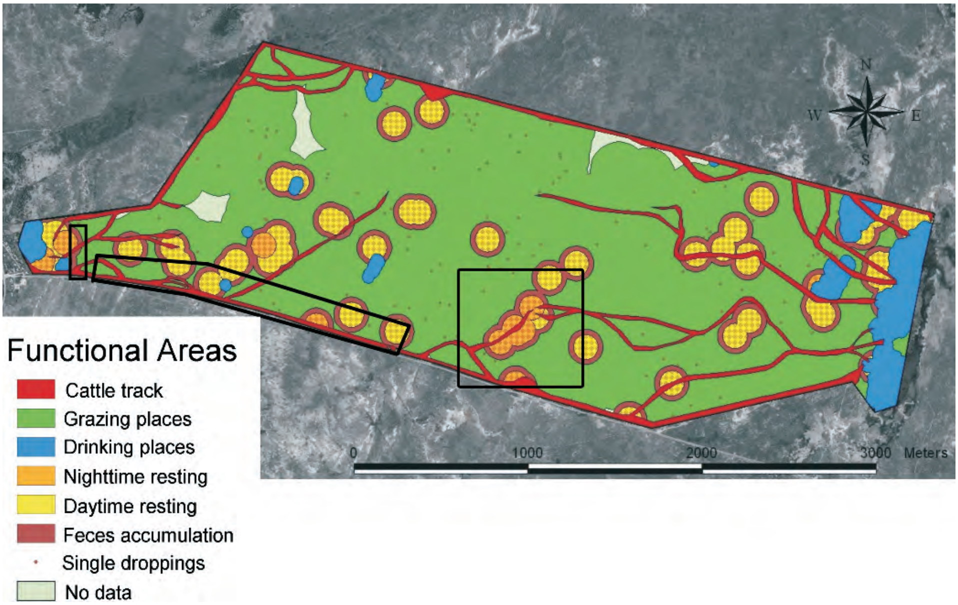

Fig. 6.45. Data collection on the cattle pasture 'Gynge'/Oeland (south Sweden) in three areas (*black squares*) representing different functional areas of the cattle herd according to Sect. 6.3

6.7.3
Results

Rhoen

On the transects of the set stocking pastures of the Thuringian Rhoen, the relative concentrations of soil nutrients (P_2O_5, K_2O, N_{total}, NH_4^+ and NO_3^-) declines markedly with distance from the resting place (Fig. 6.46). The nutrient concentrations of K_2O, P_2O_5 and NO_3^- remained almost constant in the first 20–40 m, before starting to decrease. NH_4^+ only starts to clearly decrease after 70 m.

In contrast to this, on the three investigated rest places of the two rotation pastures in the Thuringian Rhoen, no correlations were found for the relative concentrations of the investigated soil nutrients with distance from the resting place center (Table 6.44).

From the recorded plant species, three were selected as exemplary oligotrophic and four as exemplary eutrophic species (Fig. 6.47). The abundances of *Helictotrichon pratense* and *Poa pratensis angustifolia* stay fairly constant over the first 30–40 m then start to decrease. The abundances of *Deschampsia cespitosa* fluctuate relatively strongly in the first 30 m but then increase after 40 m. The distance explains 73–95% of the variances in abundance for the oligotrophic plants.

In contrast, the average abundances of eutrophic plant species decrease with the distance relative to the total distance of the long transect. The abundances fluctuate relatively strongly in the first 20 m but decrease clearly after 30 m. The distance explains 74–99% of the variances in abundance for the eutrophic plants.

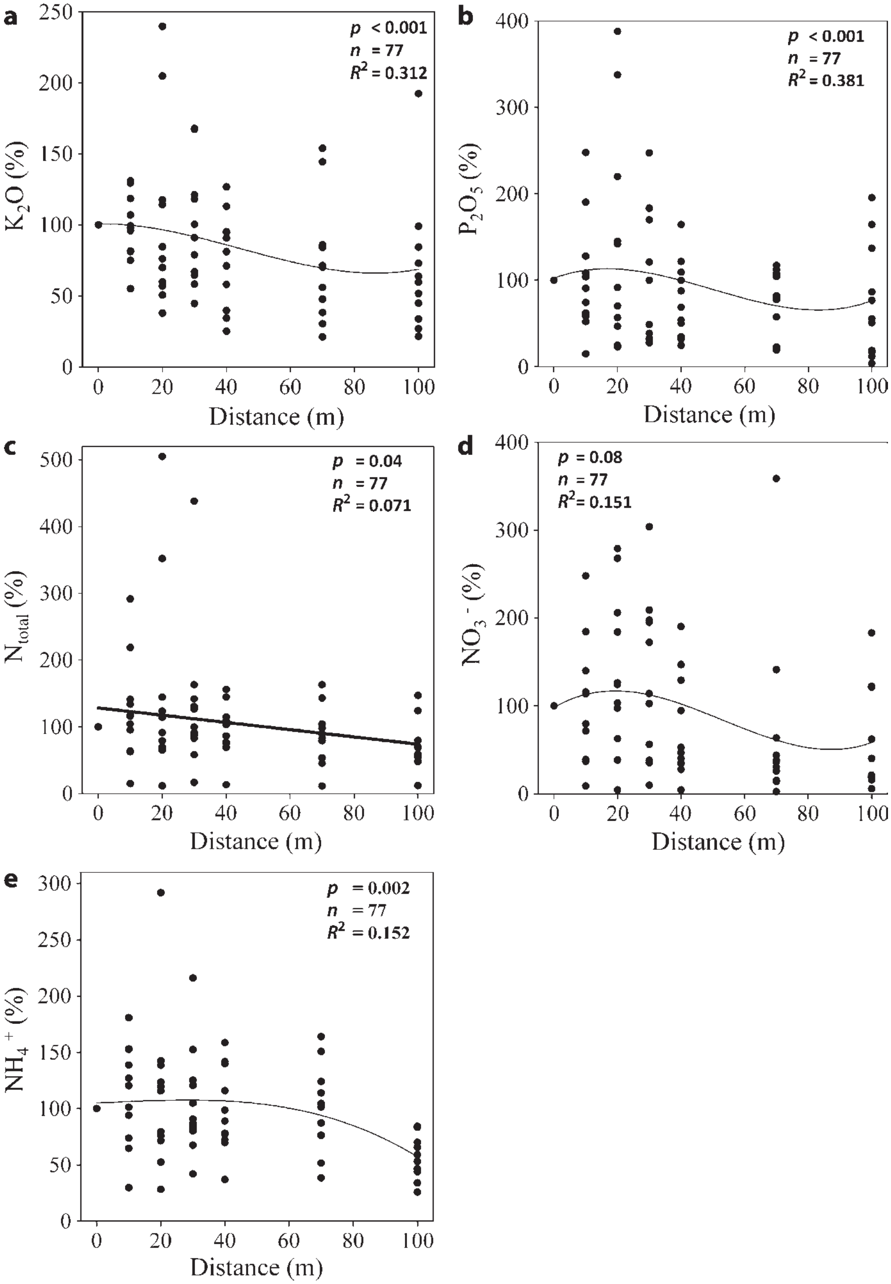

Fig. 6.46. Concentrations of nutrients in the upper soil for three set stocking pastures in the Thuringian Rhoen around cattle resting places. Basis: sample squares along transects (n = 44 for Rotenhauck and Ellenbogen, n = 14 for Hemschenberg). Correlations of the relative concentrations of the soil nutrients K_2O, P_2O_5, N_{total}, NO_3^- and NH_4^+ with distance from resting place (1st to 3rd order adjustment curves)

Table 6.44. Relative concentrations (%) of K_2O, P_2O_5, N_{total}, NO_3^- and NH_4^+ with distance from the cattle resting place center (= 0 m) on the rotation pastures of the Thuringian Rhoen. *RP:* Rotational pasture, *R:* resting place

		Distance (m)						
		0	10	20	30	40	70	100
K_2O	RP Ellenbogen R1	100	275	313	404	200	352	326
K_2O	RP Ellenbogen R2	100	76	157	126	109	47	45
K_2O	RP Rotenhauck R1	100	103	59	64	48	47	62
P_2O_5	RP Ellenbogen R1	100	723	464	196	84	347	39
P_2O_5	RP Ellenbogen R2	100	494	2883	2028	630	490	391
P_2O_5	RP Rotenhauck R1	100	46	60	36	10	37	129
N_{ges}	RP Ellenbogen R1	100	81	123	96	70	311	118
N_{ges}	RP Ellenbogen R2	100	25	37	47	36	20	12
N_{ges}	RP Rotenhauck R1	100	91	87	119	103	74	52
NO_3^-	RP Ellenbogen R1	100	103	108	122	53	311	101
NO_3^-	RP Ellenbogen R2	100	15	31	36	34	15	5
NO_3^-	RP Rotenhauck R1	100	166	166	88	110	128	75
NH_4^+	RP Ellenbogen R1	100	25	12	56	81	110	10
NH_4^+	RP Ellenbogen R2	100	23	16	4	7	3	2
NH_4^+	RP Rotenhauck R1	100	83	65	71	58	44	39

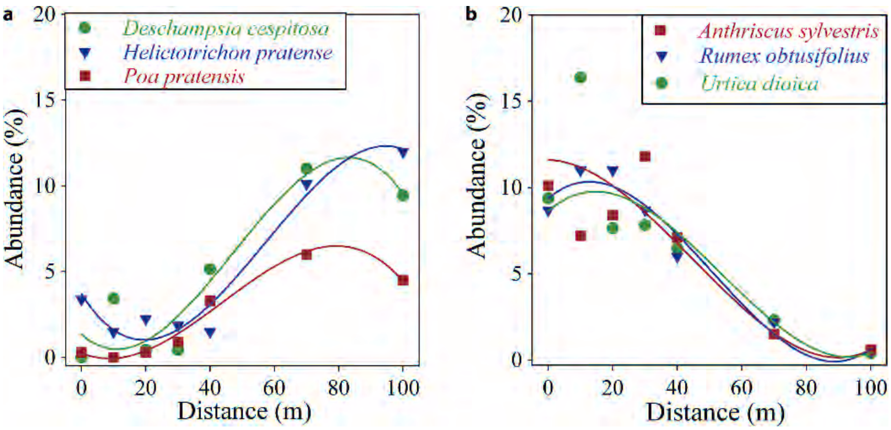

Fig. 6.47. Correlation of average abundances of the most frequently occurring oligotrophic and eutrophic plants with distance to the locations visited by the cattle in the Thuringian Rhoen (adjustment curves 2nd and 3rd class). $n = 7$. **a** Oligotrophic plants: *Deschampsia cespitosa* ($p = 0.01$, $R^2 = 0.73$), *Helictotrichon pratense* ($p = 0.03$, $R^2 = 0.85$), *Poa pratensis angustifolia* ($p = 0.02$, $R^2 = 0.95$). **b** Eutrophic plants: *Anthriscus sylvestris* ($p = 0.003$, $R^2 = 0.86$), *Rumex obtusifolius* ($p = 0.002$, $R^2 = 0.99$), *Urtica dioica* ($p = 0.02$, $R^2 = 0.74$)

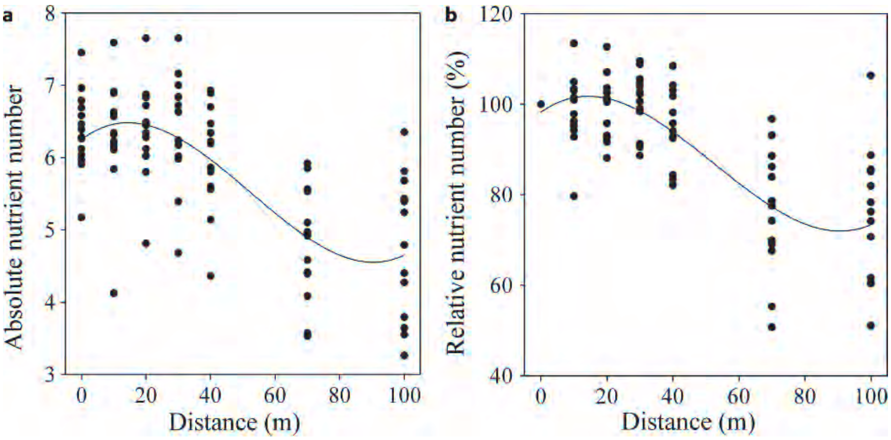

Fig. 6.48. Correlation of the average weighted nutrient numbers of the vegetation (Ellenberg et al. 2001) with the distance to the locations visited by cattle in the Thuringian Rhoen (adjustment curve 2^{nd} and 3^{rd} order). **a** Absolute nutrient numbers for all 14 long transects, **b** relative nutrient numbers for all 14 long transects

The weighted relative nutrient numbers correlate very well with distance from the resting place on both set stocking pastures and rotation pastures (Fig. 6.48). In the first 40 m, the nutrient numbers remain fairly constant before starting to decrease.

The distance explains 38–65% of the variances in nutrient numbers.

Oeland

Approximately the first 80 m of the main transect over the western resting place of the Swedish set stocking pasture cover areas which, because of their structure, are preferred by cattle as 'camps'. The remaining 70 m run through open land without woody vegetation. A cross-transect which cuts the main transect at a right-angle at 90 m and which lies outside of the actual resting place was set up to take into account values at the resting place and differences in location types (overflowing moraine left of the main transect, very shallow lime soil to the right).

The concentrations of K_2O, P_2O_5, N_{total} and NH_4^+ are clearly raised, even at the resting place itself (Fig. 6.49). Within the resting place, the concentrations of P_2O_5 and N_{total} remain fairly constant along the first 60 m of the main transect, before starting to decrease. On the other hand, the concentration of NO_3^- continuously increases with the distance (Fig. 6.50).

The eastern sampling area on Oeland, the second resting place, is characterized by a complex spatial arrangement (Fig. 6.51). The location is clearly used mainly as a regular night-time resting place (see Sect. 6.3). The cattle rest and excrete either in the center or the south-east to south-west exposed edge of the two woody areas, according to the weather situation. In the center of the woody areas, there is virtually no herbaceous, ground-cover vegetation, despite sufficient light conditions. Outside of this also, the vegetation structure is patchy in places and in wet conditions, the upper soil layer forms a consistent greasy film. The recognizable cow pat density (many decaying remains) is

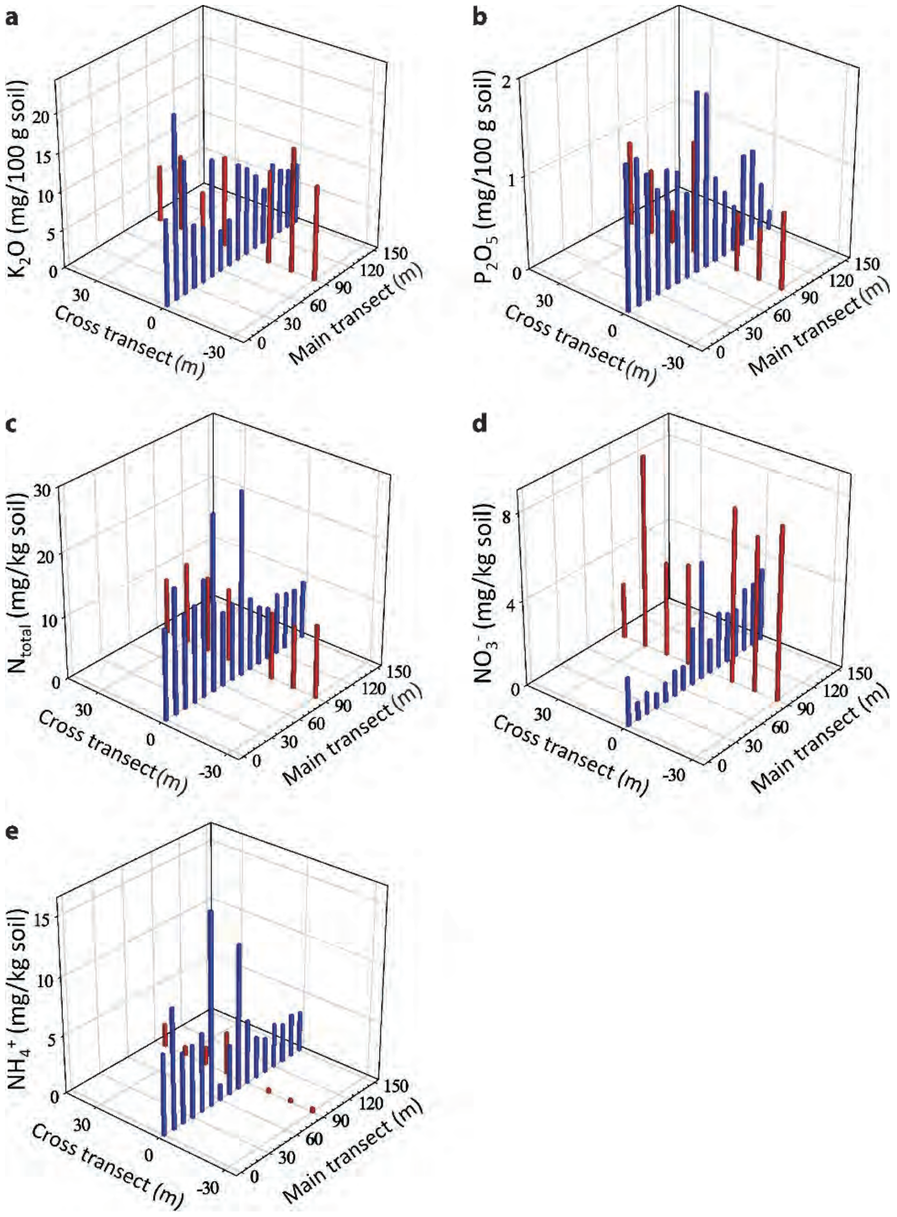

Fig. 6.49. Concentrations of K_2O, P_2O_5, N_{total}, NO_3^- and NH_4^+ along the main transect (*blue*) and the cross transect (*red*) in the western sampling area on Oeland

mainly well over 50 per 100 m^2. For a comparison with these areas, which are clearly heavily affected by excrement, the moraines and lime soil locations were investigated at selected points up to 200 m distance from the resting places.

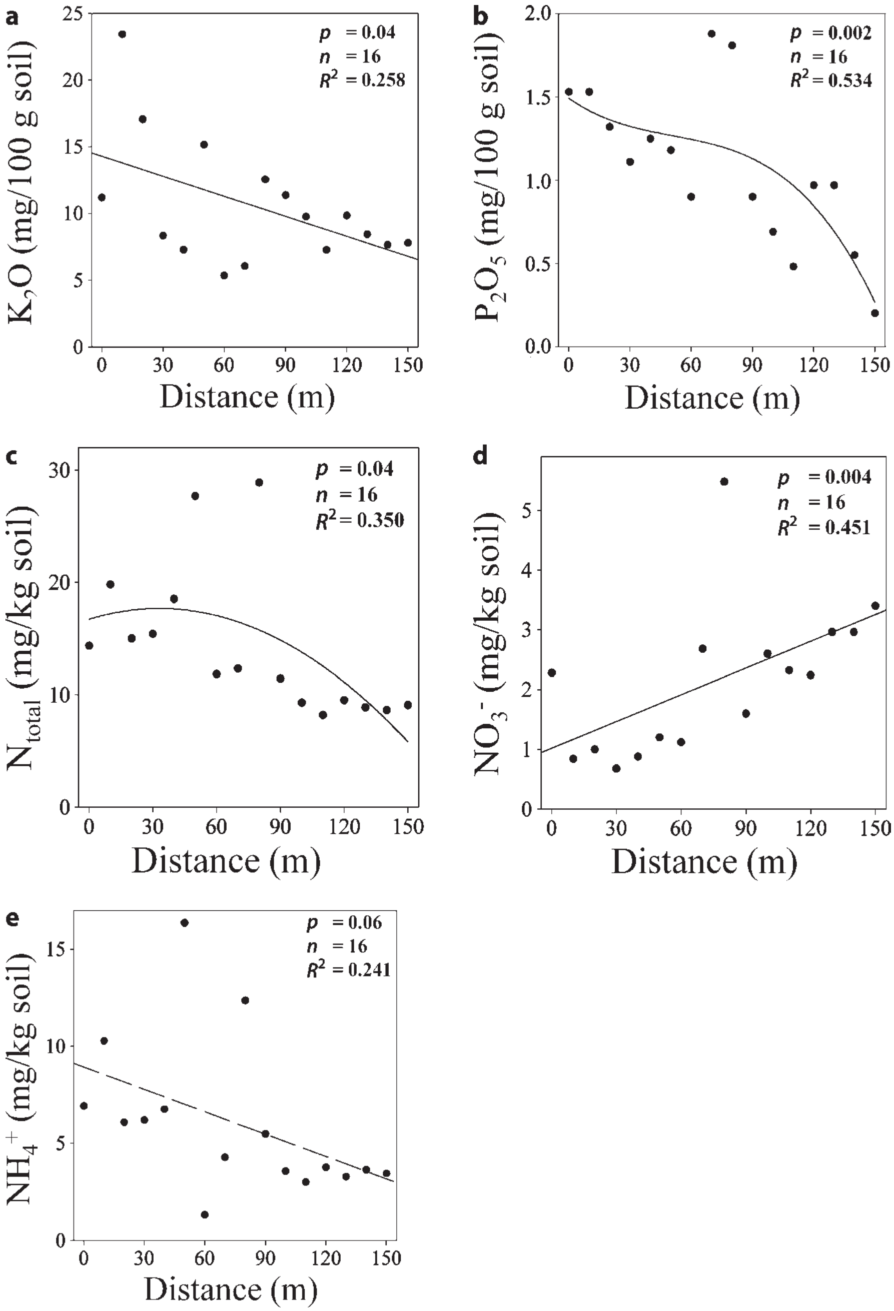

Fig. 6.50. Correlation of the concentrations of K_2O, P_2O_5, N_{total}, NO_3^- and NH_4^+ with the distance to a cattle visiting place along the main transect in the western sampling area on Oeland (adjustment curves 1st to 3rd order). The marginally significant correlation for NH_4^+ is represented as a *broken line*

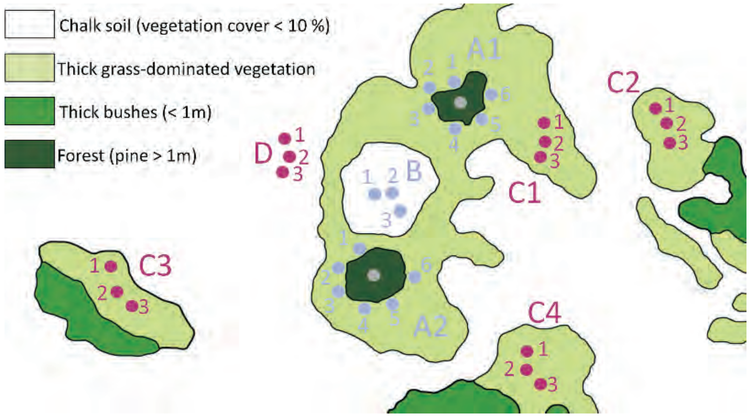

Fig. 6.51. Cartographic representation of the sampling points in the eastern sampling area on Oeland. *A1, A2:* Night-resting places, *B:* intervening day-resting place, on very shallow chalk soil, *C:* reference areas on moraines, *D:* reference area on chalk. A2 is the preferred night-resting place. The sampling points at the individual rest places (*blue*) and the little-used places (*violet*) are numbered, *grey* sampling points are in the wood (location of cattle during the night)

Table 6.45. Concentration (mg/kg) of N_{total}, NH_4^+, NO_3^-, and P_2O_5 in the eastern sampling area on Oeland. The sampling points correspond to those in Fig. 6.51

Sampling point	N_{total}	NH_4^+	NO_3^-	P_2O_5	Sampling point	N_{total}	NH_4^+	NO_3^-	P_2O_5
A.1.1	11.92	4.98	5.84	0.41	B.1.3	7.16	0.24	4.32	0.83
A.1.2	11.72	6.21	7.12	0.05	C.1.1	9.28	1.28	6.08	0.05
A.1.3	11.64	5.36	7.64	0.05	C.1.2	11.20	2.04	6.84	0.05
A.1.4	11.24	4.86	6.92	0.05	C.1.3	9.32	2.56	4.56	0.05
A.1.5	15.00	7.36	5.28	0.41	C.2.1	10.40	3.25	0.84	0.34
A.1.6	11.28	6.51	5.32	0.48	C.2.2	11.92	4.36	0.76	0.40
A.1.7	17.68	5.76	9.12	1.95	C.2.3	11.24	4.00	0.84	0.05
A.2.1	14.40	5.00	10.28	0.83	C.3.1	9.76	2.20	1.04	0.11
A.2.2	18.52	3.29	14.32	0.13	C.3.2	11.36	3.28	1.72	0.26
A.2.3	12.40	4.13	8.84	0.20	C.3.3	8.44	2.86	2.12	0.11
A.2.4	21.48	8.80	5.52	0.41	C.4.1	15.48	4.21	3.72	0.08
A.2.5	16.36	4.23	10.28	0.62	C.4.2	13.76	3.79	3.40	0.33
A.2.6	21.00	7.00	8.80	1.46	C.4.3	15.12	5.21	1.96	0.47
A.2.7	28.20	9.24	11.56	3.28	D.1.1	12.40	0.24	9.40	0.21
B.1.1	5.56	0.17	3.20	1.32	D.1.2	9.04	0.30	6.20	0.05
B.1.2	7.44	0.28	4.80	1.18	D.1.3	7.56	0.28	5.16	0.02

The determined values are clearly different between the resting places A1 and A2, and particularly for their centers (wood) and the reference areas. On moraine soils, the average values differ significantly from N_{total}, NO_3^- and P_2O_5 (Table 6.45) between the resting places (sampling point clusters A1 and A2) and the little-used places (sampling point clusters C1 to C4) and for NH_4^+, marginally significantly. On the resting places, the average values for these parameters are higher than on the little-used places. On chalk soil, the average concentration of N_{total}, NO_3^- and K_2O for rest places (sampling point cluster B) is lower than on the little-used places (sampling point cluster D), while the average P_2O_5 is higher.

Admittedly, the values between the individual survey areas for cluster C fluctuate strongly. This could be connected to the fact that more distant areas around the resting places are more frequently visited by the cattle than the rest of the pasture. Here too, there can be areas of high dung and urine loading. However, for N_{total}, NO_3^- and NH_4^+, the four absolute highest values are either in the cluster A or in the center of the resting places (wood). For P_2O_5, this finding is particularly distinctive.

6.7.4
Discussion

Between the individual pastures, there is a very high natural variance in the investigated soil factors, determined through different parent rocks and previous events. A more homogenous starting situation would have been desirable but was not possible with the selected area size. Set stocking pastures are, with respect to their locational factors, always 'unique'. However, an investigation design with smaller scale, and therefore more homogenous, ground units was ruled out from the start because on significantly smaller areas, cattle are not able to realize their area-dependent behavior.

The consistency of the findings is all the more striking. In the center of the resting places of all set stocking pastures, and frequently in the immediate surroundings, the nutrient levels are relatively high and tend to fall off with increasing distance. This is the case even when, as in the Thuringian Rhoen, the absolute values for different resting places are summarized in a data pool. Abundances and weighted nutrient numbers for selected plant species support this finding and also prove that nutrient accumulation through the livestock has significant impacts on the composition of vegetation.

During the period of the investigation, there was a closed system with respect to the nutrient balance for all of the set stocking pastures. There was no addition of feedstuff material from outside. If then, nutrient accumulates at the rest places, there must necessarily be a nutrient withdrawal from the preferred grazing areas.

Even though it has already been proved on comparable rotation pastures in other places, (Haynes and Williams 1993; Mayer et al. 2002; Schnyder et al. 2002; Spatz 2001) no clear spatial relocation of nutrients through cattle could be shown for the three rotation pastures in this investigation. The reasons for this may well be because of the relatively low spatial resolution for the small rotation pastures and the limited duration of the investigation. In the reference investigations, via drinking troughs and valley slopes, spatial behavior triggers were also relevant, which were not given here in this form. Although on rotation pastures, there would also normally be individual places of nutrient enrichment (so-called fertile spots), the ecological impacts are in fact much smaller, because through behavioral causes and the introduction of feedstuffs or through fertilizer spreading, the remaining areas of the pasture already have a high nutrient level.

Other investigations have proved a spatial separation of individual nutrients in various preferred areas for urine and dung excretion (Spatz 2001; Spatz et al. 1992). At urination places, there was an enrichment of K_2O, N_{total}, NH_4^+ and NO_3^-, while P_2O_5accumulated through dung deposition. Such a separation could not be proved in the investigation presented here. On large set stocking pastures, such findings are also hardly to be expected because of the typal behavior of the cattle. Dung and urine are usually deposited during or at the end of a rest phase and then near to the resting place. Spatial preferences of the cattle, if such exist, are canceled out through the sum of the herd behavior.

The findings from the western location on Oeland are less conclusive as would have been expected, given the popularity of this resting place (see Sect. 6.3). It should be noted here that because of a rain period before, an ephemeral shallow lake which would normally have appeared in spring only had persisted into August. After heavy rain, parts of the resting place were inundated. The flow of rainwater with soil material from the raised moraines to the lower lime soils could have led to a deposition and leaching of nitrates (Scheffer and Schachtschabel 2002). For months before the investigation, the sampling points at the distances 10 m to 60 m were located directly by the lake. Because of this, it is possible that more nitrates were washed out than in other parts of the 150 m transect (distances 70–150 m). Under anaerobic conditions in the soil, nitro-bacteria are inactive, particularly the genera *Nitrosomonas*, *Nitrosolobus*, *Nitrosospira* and *Nitrobacter*, while *Pseudomonas* and *Bacillus* are able to break down nitrates (Mengel 1991).

On the eastern location, P_2O_5 achieved high relative values, particularly at the resting places. A reason for this could be that P_2O_5 in the soil is subject to lower leaching out than K_2O, N_{total}, NH_4^+ and NO_3 (Mengel 1991; Scheffer and Schachtschabel 2002).

The findings support the assumption that cattle are able to redistribute nutrients to a significant extent, even with low stocking densities (less than 0.1 LSU ha^{-1} on the Swedish pastures). They have therefore a significant impact on the local spatial structure and heterogeneity, and therefore indirectly on the composition of the vegetation, including its spatial structure. The conditions for this are *(a)* an area size which allows the establishment of the necessary pattern of behavior with spatial separation of individual life functions, *(b)* the avoidance of introduced feedstuffs which would level out existing locational differences in the nutrient levels with a general increase in levels, and *(c)* the long-term continuity of the spatial grazing regime, as because of the typical, species-specific search pattern for particular life requirements, the same locations are selected with a high consistency.

Acknowledgments

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Chapter 7

Effects on Landscape Level

7.1

The Importance of Large-Scale Cattle Pastures As a Flower Resource in Landscapes

Michael Hauck · Christiane Stark

7.1.1

Introduction

For many insect species, grassland is an essential living and feeding habitat. Particularly for the guilds of flower-visiting insects such as wild bees and hover flies, meadows and pastures provide an irreplaceable source of nutrition. This is particularly the case in summer after the trees and shrubs have finished flowering and most of the woodland flowering plants (e.g., spring geophytes) have withered. Until the blossoming of ruderal and segetal plant species in late summer and early autumn (tansy, goldenrod, Himalayan balsam), grassland forms the main nutritional resource for life forms dependent on nectar and pollen, alongside the smaller and therefore less significant wayside edges. Although some species (honey bees and bumblebees) have the opportunity of utilizing the so-called honey-dew, that is, the sugary excretion of aphids, the insects need above all the protein-rich pollen of flowering plants. This is one of the reasons why nature conservation strategies are based on the preservation and management of species-rich grasslands. The focus of management systems here is the mowing of grassland, which is supported by numerous nature conservation and cultural landscape programs. However, one problem is not taken into account in these regimes. Because of the ever-increasing agricultural rationalization, it happens in many regions that following the set mowing times of the state programs, some farmers ‘clear cut’ large areas of valleys or whole regions within a few days using very large machines. While in earlier times, the limited scale of working the land and the low speeds of the mowing equipment (scythe mowers and before that, hand scythes) guaranteed that flower-visiting insects and other species dependent on a continuous supply of nutrients were able to relocate to adjacent areas, modern systems altered the supply of resources suddenly and on a large scale.

This investigation is based on two hypotheses:

1. In regions characterized by grassland with a high proportion of ‘contractual nature conservation’, the agricultural activity can also result in a temporary food shortage for life forms dependent on flowering plants, especially after the first grass cut.
2. Large-scale, set stocking pastures with low livestock densities relative to vegetation cover can represent an important resource for flower-visiting insects, precisely in times of shortage.

7.1.2
Methodology

An area of about 1500 ha of agricultural land in the upper valley of the Lotte, a small watercourse in the Thuringian Rhoen west of the town of Kaltensundheim was mapped according to land use and the abundance of flowers. The results were transferred to ArcView and then evaluated. Except for small, privately used parcels, the area consists of the farmland belonging to the Agrarhöfe Kaltensundheim GmbH which farms the fields and grasslands in an ecological way and participates in the cultural landscape program of the state of Thuringia over much of its area.

Through the use of high-resolution aerial photographs as the map basis and the use of direct mapping surveys on site with laptops, it was possible to achieve an accuracy of about 20 cm and therefore record small and linear structural elements. In this way, even narrow wayside edges could be considered which were relatively insignificant because of their area but which could make important flower resources available in parcels of land. In order to achieve a high temporal differentiation as well as the fine spatial resolution, as

Table 7.1. Mapped vegetation units

Vegetation unit	Description	Further differentiation
Pasture	All areas used only as pasture, mainly of the Agrarhöfe Kaltensundheim	No
Set stocking pasture	The two largest pastures of the project (see Chap. 3), which lie in the mapped area (the areas Hemschenberg and Lichtenau)	No
Cut pasture	All areas used as pasture after the first cut	No
Grassland	All residual grassed areas, predominantly meadowland	No
Sparse orchard	Small sparse orchard areas, mainly privately owned	No
Field break	All field breaks	Differentiate between way and stream breaks
Arable field	All arable fields	Recording of individual crops

Table 7.2. Recorded classes of flower cover

Class	Description	Percentage area (estimated) in %
0	No flowers	0
1	Individual flowers or small flower patches	0.5–2.9
2	Moderate flower growth or larger patches	3–4.9
3	Many flowers but with gaps or growths not yet in full bloom or past blooming	5–9.9
4	Full flower cover, corresponds to a flower-rich meadow before mowing	10–25

required by the second hypothesis, the mapping survey was repeated four times at monthly intervals, each at the beginning of the month starting with May 2003. The vegetation units listed in Table 7.1 were broken down and in some cases were further differentiated. The area recording was carried out according to units of use (hits).

Because of the huge area and the need for several repetitions, it was necessary to record the flower cover in estimate classes. For this, a five-part scale was used. Also, a non-linear scale was deliberately selected as flower visiting insects would probably react more sensitively to differences in availability at the lower end of the scale (Table 7.2).

7.1.3
Results

The mapped area of 1 550 ha of the valley is made up as follows: meadow with 342.2 ha (22.1%), normal pasture with 63.8 ha (4.1%), cut pasture with 330.6 ha (21.4%), the two

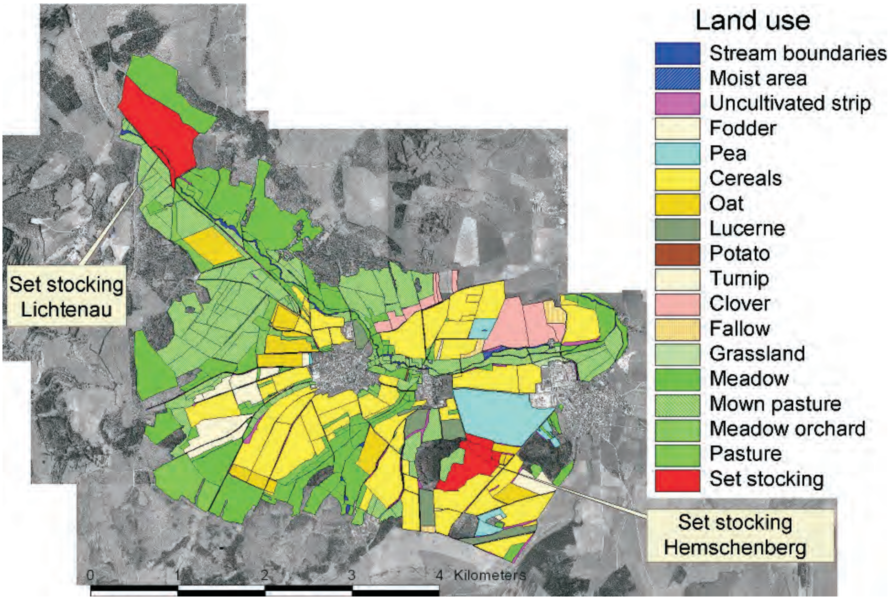


Fig. 7.1. Land use in the Lotte Valley at Kaltensundheim in Thuringia in 2003

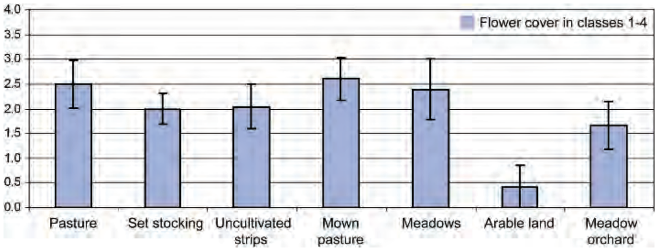


Fig. 7.2. Average flower cover (in %) of the vegetation units, mid May. *Black bars:* Simple standard deviation. $n = 518$

experimental, large set stocking pastures totaling 78.0 ha (5.1%), arable land with 671.4 ha (43.5%), small-scale sparse orchards totaling 16.3 ha (1.1%) and stream and route barriers with 37.6 ha (2.4%).

Because of the orientation to ecological production of the Agrarhöfe Kaltensundheim, which requires that at least 80% of the animal feed is provided from its own land, a large variety of arable crops was cultivated to supply the livestock. The main crops were feed barley and oats. In addition, there was a not inconsiderable proportion of legumes such as clover, peas and lucerne used to improve the protein content (Fig. 7.1).

By the first mapping survey in the middle of May 2003, there was a differentiated spatial distribution of the flower occurrences (Fig. 7.2). All of the grassland types (pasture, meadow, field break etc.), however, indicated an almost equal average flower cover (Fig. 7.3). The field breaks lie about 0.4 map points behind the general average, which can be explained by a 33% proportion of stream boundaries with later-flowering shrubs. Both of the set stocking pastures indicate a low, under-average flower cover as they

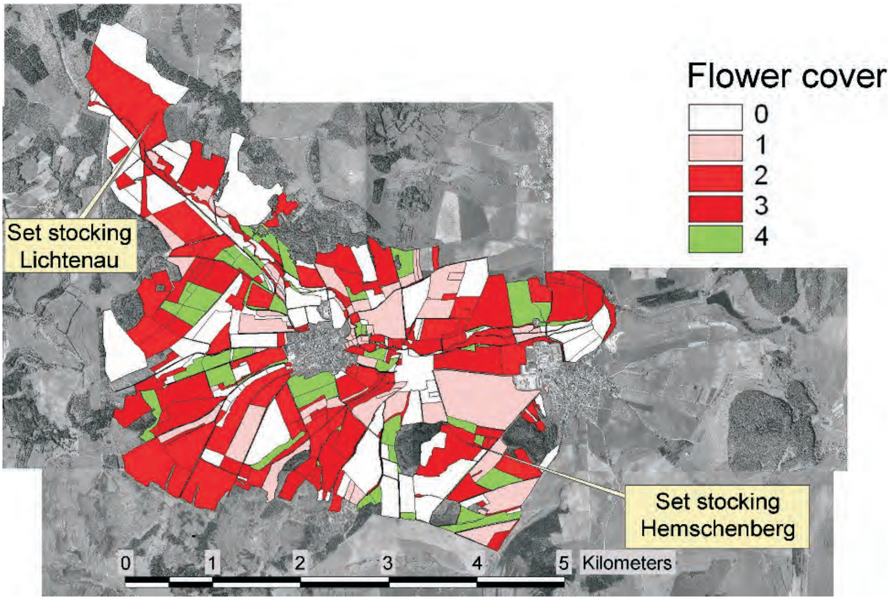


Fig. 7.3. Flower distribution in the Lotte Valley, June 2003

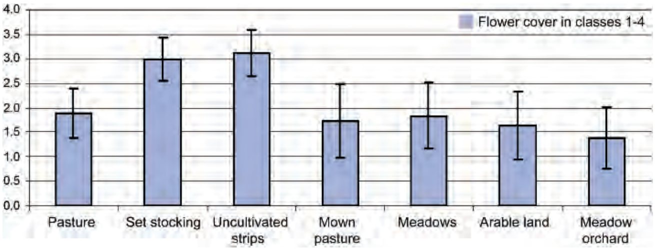


Fig. 7.4. Average flower cover (in %) of the vegetation units, June. *Black bars:* Simple standard deviation. $n = 518$

were the first of all the pastures to be stocked with cattle and the cattle had about two weeks more time to graze the biomass. The small, private, sparse orchards also lay under the average because on some areas, the harvesting of animal feed had already begun, partly by hand (scythes), while on the large areas belonging to the Agrarhöfe, work had not started, or could not start because of the contractual rules of the culture landscape program. The lower values for the arable fields can be understood from the fact that the cultivated plants (clover, etc.) and wild plants here hardly had time to form flowers after sowing and soil preparation.

In the middle of June, there was a dramatic change in the flower cover. The initially homogenous picture now showed great differences (Fig. 7.3, 7.4). Because of mowing, many fields and cut pastures are without flowers. The average values are low, the standard deviation on the other hand high, because not all areas have been mowed. The field breaks now start to blossom rapidly and on the large set stocking pastures, the few animals (set stocking Lichtenau 1 LSU, set stocking Hemschenberg 0.6–0.7 LSU) cannot completely exhaust the supply of fast-growing vegetation at

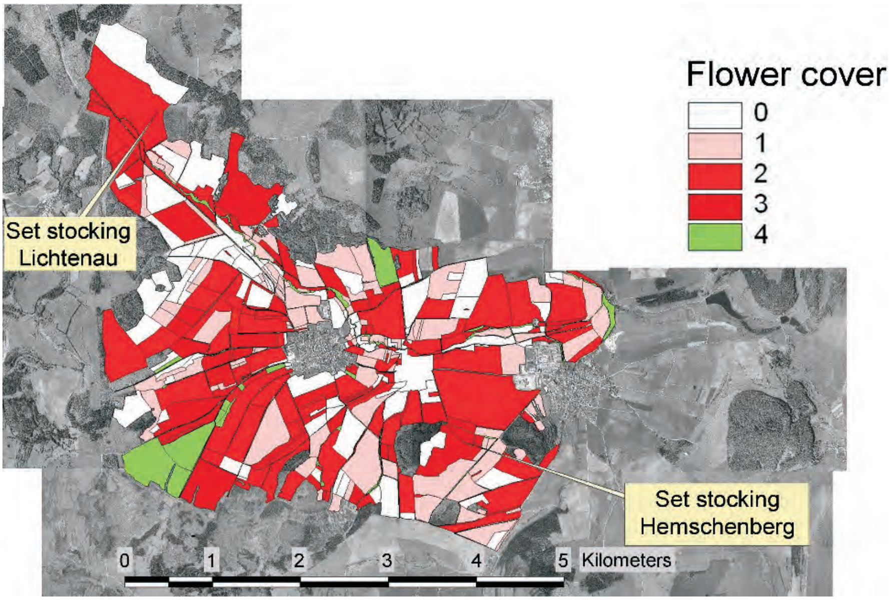
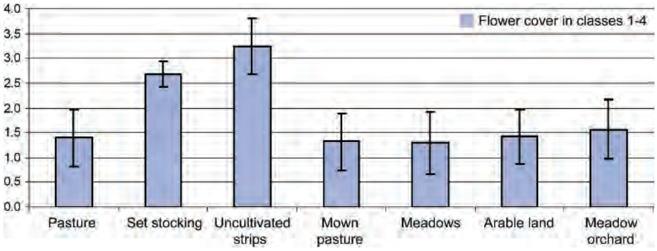


Fig. 7.5. Flower distribution in the Lotte Valley, mid July 2003

Fig. 7.6. Average flower cover (in %) of the vegetation units, July. *Black bars:* Simple standard deviation. *n* = 518



this time. However, on the traditionally stocked rotation pastures, the pressure of grazing is noticeable.

The situation in July (Fig. 7.5) is marked by a further reduction in the numbers of flowers on the pastures (0.5 map points), cut pastures (0.4 map points), and meadows (0.5 map points), (Fig. 7.6). Also on the set stocking pasture, there is a lower degree of reduction just as on the arable fields. At this point in time the crops have not been harvested. The reductions here are therefore for reasons of flower phenology. During this time, the field breaks, especially those formed by streams, were increasing in flower intensity and together with the set stocking pastures, represented the largest flower availability by some distance.

In August finally, the situation for flower-visiting insects had drastically deteriorated (Fig. 7.7). The crops had been harvested and meadows, pastures and cut pastures as well as sparse orchards lay at only 0.5–0.7 map points (Fig. 7.8). Although in places, the meadows had now had several weeks to produce new growths, this only happened

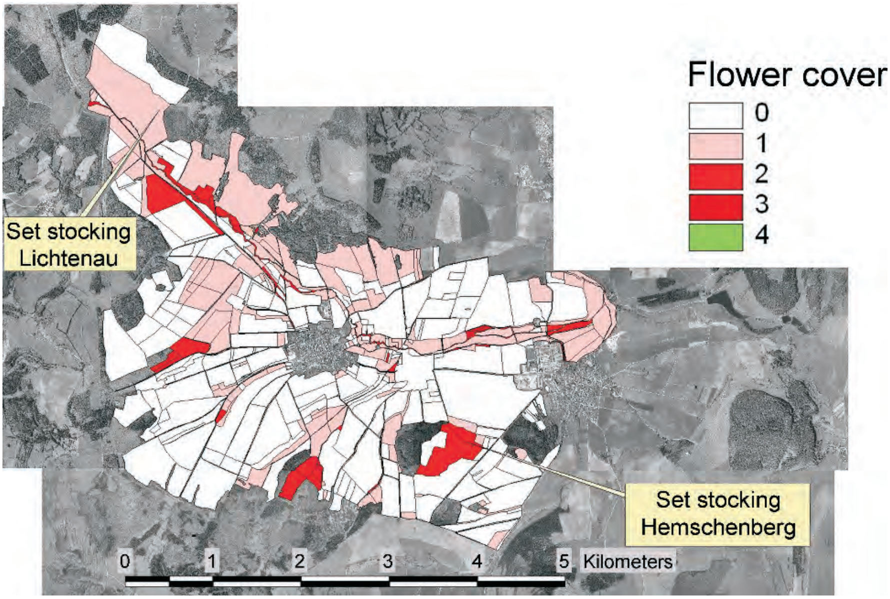


Fig. 7.7. Flower distribution in August 2003

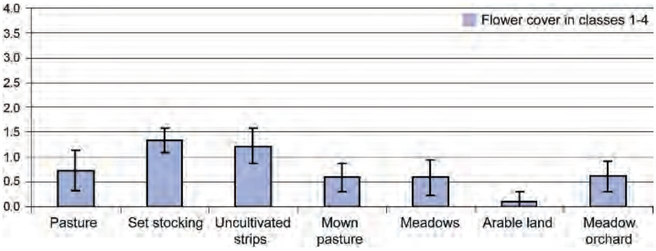
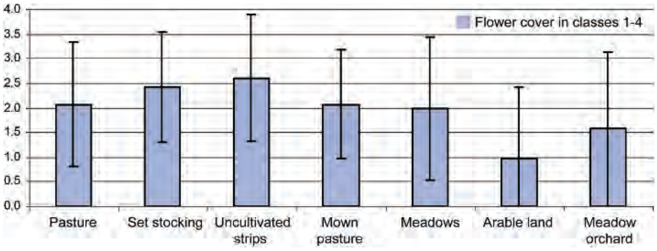


Fig. 7.8.
Average flower cover (in %) of the vegetation units, August. *Black bars:* Simple standard deviation. $n = 518$

in the areas alongside streams because of the extreme heat and dryness of the summer in 2003, which dried out grazed and mowed land very quickly. The large set stocking pastures too were affected by this but the large amount of biomass present (e.g., grazing residues, clumps etc.) meant that some shaded plants could produce flowers. Also on the 'unmanaged' large set stocking pastures, there were many thistle species (woolly thistle, carline thistle, corn thistle) which had withstood the hot and dry conditions and were able to blossom. So it was that the only large area away from the Lotte or its tributaries, that is, distant from groundwater, was the hilltop pasture at Hemschenberg. Only the field breaks could achieve a comparable value, but only along the stream boundaries (single value: 1.8 map points), while the field breaks in the fields along routes were almost completely dried out (0.6 map points).

Many flower-visiting insects may have been capable of using their greater mobility to compensate the high spatial-temporal dynamic of the resource availability

Fig. 7.9. Flower cover for the vegetation units determined over 4 months. *Black bars:* Simple standard deviation. $n = 518$



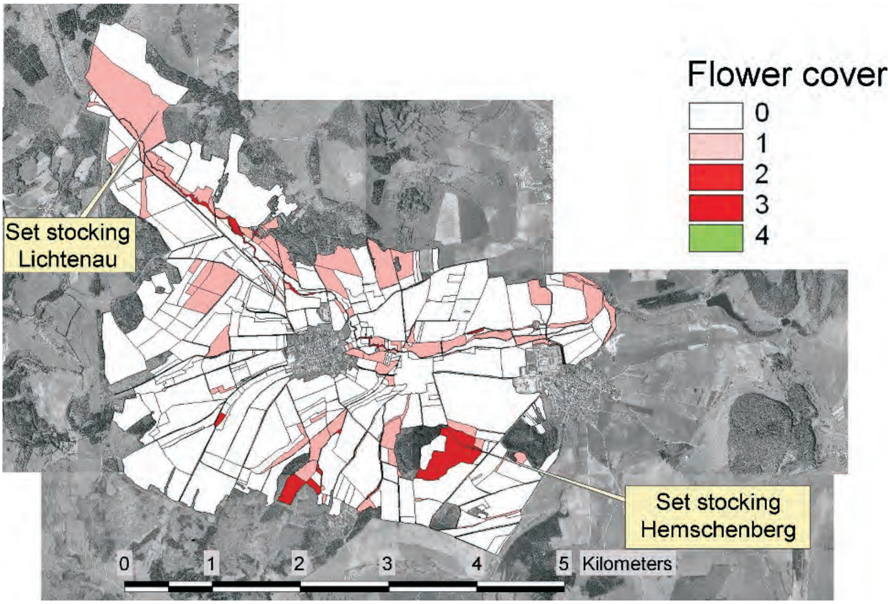


Fig. 7.10. Continuity of flower cover in the investigation period May to August 2003. The relevant lowest values from the four surveys are shown. No area consistently achieved category 4

through shift to other parts of the landscape. Others are dependent on continuity in the particular location. The average values for all four surveys provide information on the local continuity of the flower availability (Fig. 7.9). The set stocking pastures and the field barriers give the best results, although the standard deviations are very high. This can be explained by the fact that on the individual areas of a category, a very different continuity was achieved because of location and land use. Only water meadows and pastures, field breaks and set stocking pastures offer flowers throughout the whole vegetation period (Fig. 7.10). The set stocking pasture Hemschenberg did not fall under 2 map points and is therefore the largest extensive area with a consistently good nutritional availability (50.1% of the total area with values always over 2). Only the field breaks along streams and one wet meadow achieved similar values.

7.1.4
Conclusions

With respect to the weather situation, the summer of 2003 was certainly an exception (particularly the extreme dryness at the height of the season). The extremely low flower density on meadows and pastures and the dried-out waysides were clearly a result of the weather conditions. However, the findings have shed light on several important aspects:

1. Pastures and cut pastures provide a continuous supply of nutrition for flower-visiting insects.
2. Biologically-farmed fields can provide a good flower availability up to harvest time, even if the crops themselves do not provide nectar.
3. Large set stocking pastures can make available an excellent and continuous supply of flowers, even if the weather conditions are extremely hot and dry. In such conditions, they create extensive ‘flower islands’ in an otherwise almost completely flower-free landscape.
4. With the climatic conditions such as were found in 2003, field breaks formed by streams represent the only linear structures which can continue to provide a networked structure.
5. Particularly in hot summers, there is a serious shortage of nutrition for flower-visiting insects after the hay harvest because the second growth does not take place.

The entire investigation area was biologically farmed. In a comparable low-mountain valley with conventional agriculture, the results would have been considerably more in favor of the large set stocking pastures. There would hardly be any wild herbaceous plants in the arable fields and there would be less cultivation of flowering crops (lucerne etc.). Secondly, the favorable meadow locations would be used as multi-cut meadows through the application of fertilizer, meaning clearly less flowering plants and less opportunity for them to flower because of repeated mowing. Furthermore, the field breaks would be indirectly adversely affected through the application of fertilizer and herbicides.

7.2
Sheep: a Functional Corridor System

Burkhard Beinlich · Harald Plachter

7.2.1
Introduction

The structural fragmentation of habitats and the resulting isolation of populations is considered as one of the decisive factors for the decline in wild animal and plant species (Gilpin and Hanski 1991; Merriam and Wegner 1992; Opdam et al. 1993; Saunders et al. 1991). An important objective of nature conservation is therefore to improve again the connectivity between populations via habitat corridors. Connectivity between populations has a landscape-structural and a functional component. The latter component is, among other things, dependent on the dispersion abilities of the individual species and the efforts of individuals to change location, which, because of internal or external factors affecting the populations, may be subject to strong fluctuations. A further possibility is the passive dispersion via vectors. For plants, the dispersal of diaspores through wind or water courses is widespread (cf. Bonn and Poschlod 1998). Even for animals, a transcontinental dispersion via passive routes has been described (see e.g., Kowarik 2003).

Such a passive long-distance transportation can exceed the biological capacities of a species to active dispersion by many orders of magnitude. The importance of such phenomena for the connectivity of populations, the new occupation of habitats and with that, the survival probabilities of a species at the landscape level has only been systematically researched in the last few years (e.g., Dörge et al. 1999; Tenzer 2004). Livestock, and here again, sheep, can play a significant role (Beinlich 1997, 2001; Fischer et al. 1995, 1996; Warkus et al. 1997).

7.2.2
Nomadic Forms of Livestock Keeping

Traditional livestock-keeping cultures are forced to adapt themselves to the life needs of their domestic animals. In places where the environment does not offer all-year-round favorable nutritional conditions to the livestock, such as in arid (sheep) and boreal (reindeer) zones, nomadic culture forms were the consequence. They arose in several continents independently of each other. The human annual cycle traces that of the livestock. Such nomadic livestock keeping is, however, in no way just restricted to regions with extreme climatic conditions. Also in many parts of the temperate climate zone, the quality of grazing fluctuates strongly over the course of a year. The consequence of this is that also in large areas of Europe, nomadic forms of livestock keeping had become established at an early period. In contrast to other parts of the world, however, permanent settlements were maintained from which the livestock could be taken by shepherds to spatially separate summer and winter pastures. This phenomenon of transhumance is spread across many parts of Europe and has be-

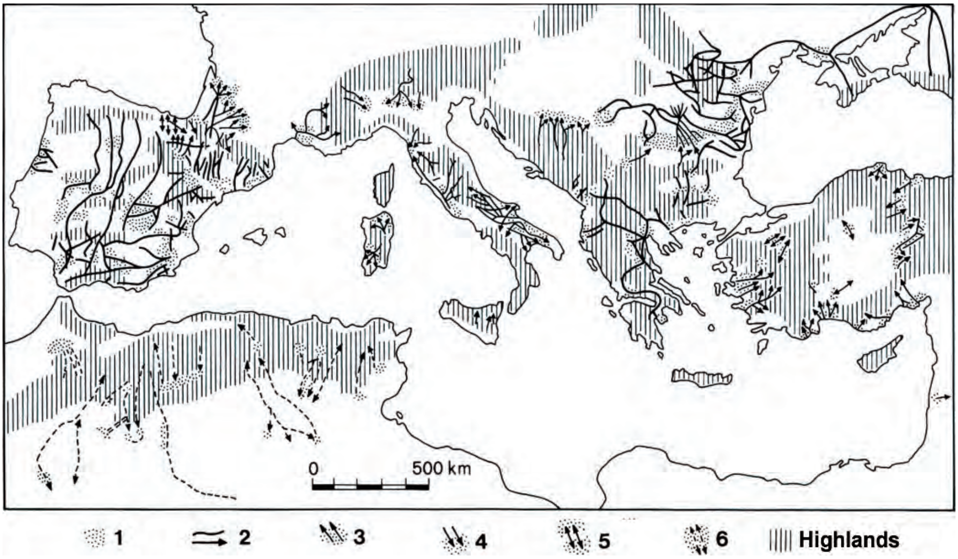


Fig. 7.11. Transhumance in the Mediterranean area. *1:* Winter pastures, *2:* transhumance routes, *3:* direction of migration, *4:* cattle herds belong to lowland dwellers: Transhumance routes lead to highland, *5:* cattle herds belong to highland dwellers: transhumance routes lead to lowland, *6:* undifferentiated, *7:* cattle herds belong to mid-level settlements: transhumance routes lead to both highland and lowland (from Schultz 1988, according to Grigg 1974)

come established mainly where productive (summer) mountain or hill pastures and lowlands with low snow levels (winter pastures) border each other (Figs. 7.11, 7.12) (cf. Jacobeit 1987; Schoerner 1936; Schultz 1988). The distances between the individual pasturelands could vary a lot here. They range from a few kilometers to several hundred kilometers. The transport of animals to slaughter, often to the main towns, took place through roaming herds.

In historical times, a wide spectrum of different keeping variants existed, ranging from actual transhumance with permanent settlements to semi-stationed and station systems, in which the livestock returned to the stalls in autumn or in the same evening. It is characteristic of these keeping systems that the livestock are normally kept in shepherded herds and cover considerable distances within short times.

Today, such keeping systems have largely disappeared from Europe. Wandering sheep herds exist in only a few regions in the traditional sense, or are parts of attempts at reintroduction (e.g., on the Spanish peninsula where the old drove roads, the so-called Kings' ways or 'Cañadas' have been brought back into use (Fig. 7.13). Where shepherding actually occurs, the sheep farming has gone over more and more to semi-stationed forms and with that, to significantly smaller action radiuses. In the high mountain regions, the traditional dairy cattle farming (alpine dairies), which are in principle also transhumance systems, has largely been replaced with young cattle farming. Overall, the once very wide spectrum of grazing forms has drastically narrowed in the past years, as is generally the case throughout agriculture.

Fig. 7.12.
Historical roaming herds in West Germany and neighboring areas (from: Hornberger 1959, redrawn)

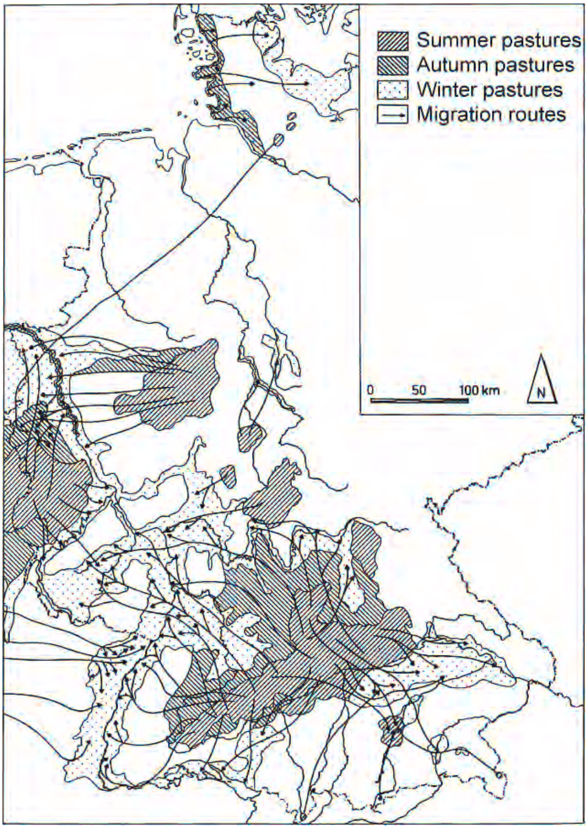
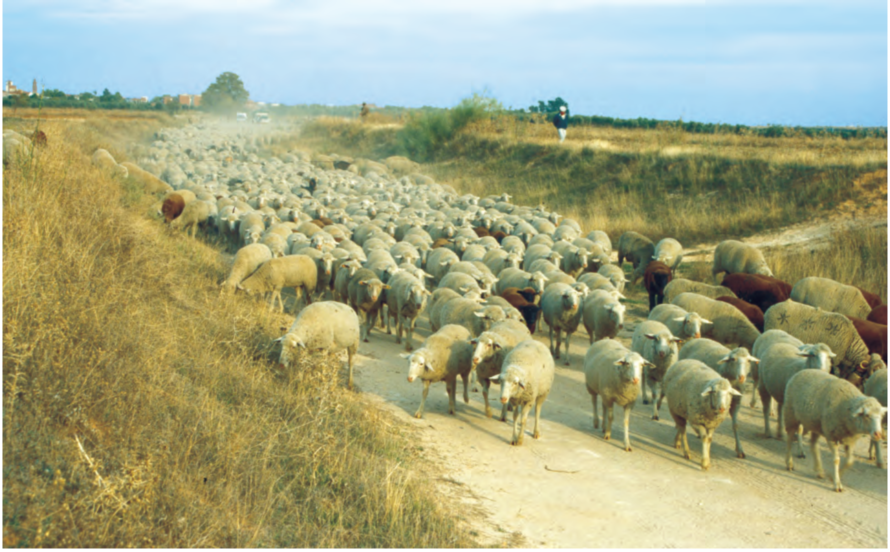


Fig. 7.13.
Sheep driving on one of the historical 'Cañadas' in Spain (photo: B. Beinlich)
▼



7.2.3
Sheep As Vectors

Because of several morphological and ethological qualities, sheep offer particularly favorable conditions for the long-distance transport of animal and plant dispersion units. They possess a thick, long coat and separated hooves (cloven-hoofed) which are able to take up dispersion units. Furthermore, the physiology of the stomach and intestinal tract make it possible for diaspores of numerous species to pass unharmed through the digestive system. The herd structures in which they are kept lead to a comparably large disturbance of mobile animal species which by chance can jump onto the bodies of nearby sheep and be transported further. In the spectrum of the grazing types, the predominant type is poor, frequently sunny grassland, which increases the chances that a dispersion unit can find itself in a similar, suitable habitat after transportation. Also, the connecting drove roads consist as a rule of different variants of poor grassland. Other ecosystem types, particularly woody vegetation, are avoided by the shepherds as animals can become lost very quickly in areas of restricted visibility.

7.2.4
Results

In the coat of a single sheep which was part of a roaming flock in southern Germany, 8 511 diaspores from 85 vascular plant species were detected in 16 coat analyses over a three-month period. 70.5% of the total diaspore number originated from sweet grasses (Poaceae). Among the dicotyledons were many typical species from calcareous grass-

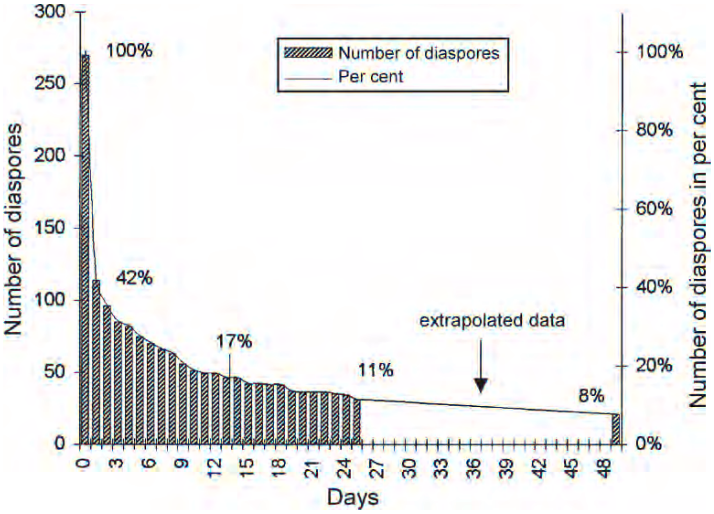


Fig. 7.14. Number and percentage of marked diaspores of *Bromus erectus* in the coats of a shepherded flock of sheep in southern Germany (from Fischer et al. 1995)

lands such as *Thymus pulegioides*, *Galium verum*, *Medicago lupulina*, *Scabiosa columbaria* and *Origanum vulgare* (Fischer et al. 1995, 1996). In the same investigation, marked diaspores were placed on two sheep in a flock and their locations regularly checked (Fig. 7.14). Even after seven months and a distance covered totaling over 100 km, individual marked diaspores from *Bromus erectus* and *Helianthemum nummularium* could be found. In the hooves of 30 investigated sheep in the same flock, 382 diaspores from 48 vascular plant species were determined, including low-growing species such as *Thymus pulegioides*, *Euphrasia rostkoviana* and *Gentiana verna*. From dung samples, germ buds from 27 vascular plant species were found which had passed undamaged through the sheep intestinal tract.

In further studies, the transport of grasshoppers (Orthoptera, Saltatoria) by roaming sheep flocks was investigated (Beinlich 1997; Fischer et al. 1995; Warkus et al. 1997). From the results of this work, up to 25 grasshoppers could be recorded simultaneously present on one sheep. The numbers were significantly higher when other sheep were close by (jumping through disturbance). In total, at least 14 out of 21 locally-occurring species on poor grasslands could be found on the sheep.

In order to determine the transport times, a total of 700 dye-marked grasshoppers from 6 species common to poor grasslands were placed on tame sheep. The 'transporter sheep' was continuously observed until the last marked grasshopper had left the coat. The duration of the stay was generally under 30 min although occasionally, grasshopper individuals remained more than 1½ h on the back of the sheep and rode there for a distance of almost 700 m (Fig. 7.15). Particularly long residence times were found

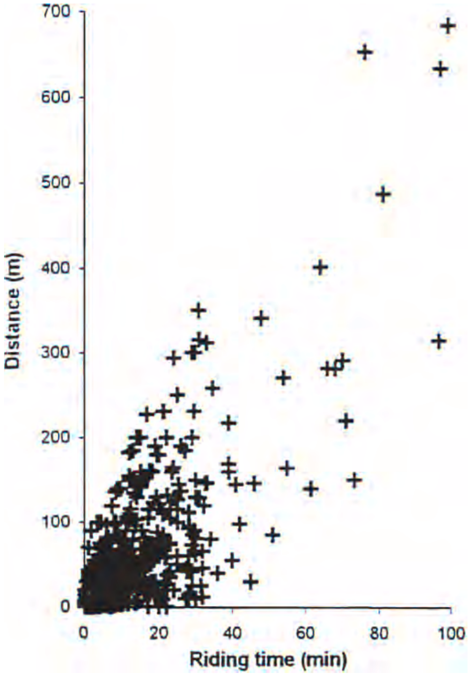


Fig. 7.15.
Correlation of residence durations on the backs of sheep and the distance covered by 701 grasshoppers (*C. biguttulus*, *C. parallelus*, *E. brachyptera*, *M. bicolor*, *M. roeselii*, *S. lineatus*), which were placed on a tame sheep in a shepherded flock in southern Germany (from Warkus et al. 1997)

Table 7.3. Animal groups and species (without grasshoppers), which were transported in or on sheep coats (from Fischer et al. 1995)

Taxon	Species
Reptilia	*Lacerta agilis*
Coleoptera	*Sitonia* sp.
Heteroptera	*Alydus calcaratus* *Carpocoris pupuripennis*
Araneae	*Erigone dentipalpis* *Erigone atra*
Gastropoda	*Pupilla muscorum* *Helicella itala* *Trichia* cf. *plebeja* cf. *Aegopinella* sp.

for *Chorthippus biguttulus*, *C. parallelus* and *Metrioptera bicolor*, each of the three species with flightless females.

'Mark-and-recapture' experiments proved that up to 4% of a grasshopper population can be 'carried off' by a flock of sheep, although as a rule, the proportion lies under one percent (Beinlich 1997).

The transport function for wild animals is however by no means restricted to grasshoppers. On the coats of sheep, among other things, beetles, spiders and even lizards have been found (Fischer et al. 1995) (Table 7.3). A young specimen of *Lacerta agilis* changed transport sheep twice during a 22-minute ride and even with hefty movements by the sheep, showed no flight reaction. The individual sheep exposed absolutely no signs of treating the transported animal as a threat. Grasshoppers stridulate on sheep coats and individual males have been observed attempting copulation.

Small snails (species such as *Pupilla* or young animals) are regularly transported between the hooves of the sheep (Fischer et al. 1995). The results from dummy experiments (artificial sheep dummies which were moved over the ground as naturally as possible) showed that the snails (a few millimeters long) were regularly transported over 100 m in damp or wet weather conditions (Walther and Beinlich 1997, quoted in Beinlich 2001). The longest proven stretch amounted to 650 m. The method of dispersion certainly exceeds the possibilities of active migration, which would be under a meter, by several orders of magnitude.

7.2.5
Conclusions

Until now, systematic investigations on the distances that livestock transport dispersion units of wild animals and plants have only considered sheep. However, it can be assumed that other domestic species, particularly cattle, goats and in other parts of the world, camels or llamas, fulfill similar ecological functions (cf. Stender et al. 1997). In this respect, however, it is sheep which quantitatively have the greatest significance because of the specific combination of biological qualities and keeping forms.

While mechanisms and ways for the long-distance transport of dispersion units have massively increased in our modern society compared to the historical situation (see also Bonn and Poschlod 1998), these modern forms of transport, however, almost always end up in 'ecological dead ends' (slaughterhouses warehouses, airports, harbors, town centers etc.). Potential 'dispersers' reach neither suitable habitats nor support populations of the same wild species by additional individuals. In contrast however, it is characteristic of the historical forms of livestock keeping that they connect together uniform or similar habitats (pasturelands). The chances that transported individuals can find suitable living or colonization conditions are therefore disproportionately greater.

The relevant data remain incomplete. However, even with very cautious interpretations of the results, the data makes clear the huge significance which the passive transportation of dispersion units through livestock has for both plants and animals. It is probable that livestock have taken over the ecological function which was previously fulfilled by wild mammals which also undertook regular migrations. A natural ecological process was replaced by one which was anthropogenically controlled, although of equal value. Certainly not without qualitative changes, but with respect to the dimension, in no way weaker and more likely strengthened.

In times in which transhumance was still widespread (middle of the nineteenth century), in the 'Germany Reich' alone there were 29.7 million sheep, of which 5.1 million were part of roaming flocks (Freyer 1918; Schoerner 1936). If we calculate from the presented scientific findings and apply only one percent of the quantities, this still indicates transport events in billions per year. It is important to see that species are also certainly included here that possess only a limited dispersion capacity (e.g., snails, wing-reduced grasshoppers, plant diaspores without other morphological adaptations to vector dispersion). Nomadic and semi-nomadic forms of livestock keeping were – and remain so today, where such forms persist – therefore, a very significant ecological process which supported the stability of populations at the landscape level. The striking species abundance of many grazed grasslands and bush formations in Europe could find in this an ecological explanation. It is clear that independent of any structural configuration, a functional ecological network arose on such pasturelands over thousands of years, brought about by the transport qualities of the grazing livestock.

Because of the high personal effort and the poor financial reward on international markets, transhumance systems of livestock keeping have in the meantime virtually disappeared from Europe (cf. Hampicke and Tampe 1995). In other continents, such systems are likewise in decline. The agricultural paradigm, that stationary (stall) forms of keeping are modern and 'efficient' while shepherded systems belong to the past strengthens this process just as much as modern life patterns which require a permanent abode for their realization. However, there is concern that with this, an ecological factor is disappearing from the landscapes which for many species was perhaps far more important than any structural landscape habitat corridor. Firstly administered by wild mammals, then by livestock, there is now apparently no realistic alternative as to how this ecological function could be continued in the future. The profession of 'roaming shepherd' appears today as unattractive as hardly any other, particularly under the conditions of the EU agricultural policy.

With respect to the framework conditions, such a profession is, however, in no way less attractive than others. The central problem is the low yields from the current products (see Sect. 8.1). Structural (habitat-dependent) landscape network systems are even now supported by high public investment. For the functional-ecological networks via livestock, there is no corresponding allocation.

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7.3
Historical and Current Grazing Systems in the East Carpathians (Ukraine)

Harald Plachter · Rolf Satzger · Josif Tsaryk

7.3.1
Introduction

In Central Europe, many of the ecosystems and mosaic landscapes considered worthy of protection arose through the intensive grazing influences of livestock in historical times (Beinlich and Plachter 1995; Bignal and McCracken 2000; Konold 1996; Plachter 1999; Radlmair et al. 1999; Redecker et al. 2002; Webb 1999). The starting point for conservation strategies is consequently the differentiated understanding about the grazing influences prevalent at those times, including the management systems and grazing variants, and secondary uses which have arisen in the meantime. In Western Europe, a reconstruction is only possible in a qualified sense because such grazing systems have for a long time been largely abandoned and the historical sources (chronicles, maps etc.) can only give a fragmentary picture.

Despite high mechanization and the socialization of agriculture, many peripheral regions of the former Soviet Union have preserved elements of historical grazing systems (mainly aimed at subsistence farming) until the present day. Following the breakup of the Soviet Union and arising from the socio-economic depression connected with the general loss of machinery, mineral fertilizers and plant protection chemicals, such grazing forms have increased in significance for the local populations over the last few decades as an important form of subsistence (Elligsen et al. 1998; Penkraitis 1994). Peripheral areas of the former Soviet Union are therefore good models for the construction of historical grazing forms in the western part of Central Europe and for the analysis and evaluation of their effects on nature.

The Ukrainian East Carpathians form a mountain range which is particularly suitable for an analysis of this sort. Climate, locational factors (e.g., soils), species numbers and vegetation structure are immediately comparable to those found in many parts of western Central Europe. Here too, as in all the post-Soviet states, there has been a return to subsistence production and supply systems over the last twenty years. However, because of the economic proximity to the EU, it was not so drastic here as in other parts of the former Soviet Union (cf. Didebulidze and Plachter 2002).

7.3.2
Methodology

In the years 1999 and 2000, we investigated the historical and current landscape structure in an area of the upper Dnister Valley about 20 km^2 in size, on the east side of the Carpathians (the communities Busovesko and Werchnej Luschok, Oblast Lviv; in the following – IA 1). The focus was on livestock grazing. As part of this, comparison data on current land uses were obtained, covering a section of the middle Dnister about 100 km south of Lviv (in the following – IA 2) (cf. Horban et al. 2000; Satzger 2002; Tsaryk and Tsaryk 2002; Chap. 3 in this book).

In both investigation areas, available local documents (maps, community chronicles, statistics from local authorities) were evaluated, and local people were interviewed. In IA 1, an actual land-use mapping survey (2000) was carried out. The results were transferred to a digital use map with Desktop-GIS ArcView. This map was the basis for the calculation of area proportions of individual use forms. In addition, 21 cattle herders were interviewed in detail using standardized questionnaires (for the method, see Schnell 1995). The basis of the personal interviews was a questionnaire with a total of 20 questions, including questions about the current grazing management and pasture care as well as past changes at intervals of 10/20/40/60 years, and finally, an estimate of the efficiency of the grazing management. The questionnaire was conducted in the Ukrainian language.

IA 1 lies within the eastern plain of the Carpathians at low-range mountain height of about 370 m to about 650 m a.s.l., in the upper reaches of the Dnister Valley. The climate is Central European, sub-continental with yearly average temperatures of 6.5 °C and precipitation of about 800 mm yr^{-1}. In the potential natural vegetation, red beech (*Fagus sylvatica*) would be dominant. Not least because of the cultural and land use history, (for a long time, the AI was part of the Austro-Hungarian empire), the landscape structures are very similar to those in western Central Europe. The area is therefore largely comparable to low mountain ranges of corresponding geology in western Central Europe. In IA, the proportion of private agriculture has always remained relatively high, despite collectivization. Additionally, the social structure of the villages corresponds more closely with the situation in Western Europe rather than with a 'socialized' system.

IA 2 lies in the middle reaches of the Dnister, south-east of Ivano-Frankivs'k and comprises the communities Koropetz, Vystra and Gorigljadi. The winding middle stretch of the Dnister characterizes the hilly area, with in places, extensive flood plains along runoff slopes and river meanders. The diverse soil spectrum ranges from fluvial sediments to Loess deposits, from brown earths to lime soils. The AI 2 area can be considered as typical for the type of use in 'better' developed regions of Ukraine in the lower reaches and was selected for the investigation because of this. The socialization process here has left more fundamental traces in land utilization and communal decision-making processes than in AI 1. 'Historical knowledge' about the mechanisms of individual or communal self-sufficiency has clearly diminished over time.

7.3.3
Current and Recent Land Use

General Situation

The proportion of farmed land in Ukraine in the year 2000 amounted to 69%, of which 17% was hay meadow and pasture (Penkaitis 1994). After the Second World War, livestock production in Ukraine rose sharply. The number of cattle reached 25.4 million in 1980, the highest level. Since 1981, numbers of livestock have declined (1997: 15.3 million animals). Since 1990, cattle have been increasingly kept in private possession. On the whole, however, the privatization of agriculture has not reached the levels of other post-Soviet states (Table 7.4).

Table 7.4. Percentage of livestock numbers in privately owned secondary income farms in Ukraine, 1980 to 1992 (from Penkaitis 1994)

Year	1980	1990	1991	1992
Cattle	15.3	14.4	14.9	16.2
Sheep and goats	6.9	14.9	18	22.3

Until 2001 in Ukraine, agriculture has been only partly privatized. The cooperative farms have mainly continued to operate (in part, legally privatized), although in peripheral regions, at best with equal ranking to low-level private agriculture. Traditional land use forms have been taken up again and this is demanding increasingly more land. This development is not fundamentally new but signifies only a change of emphasis. During the Soviet Union times also, private farming for self-supply was allowed within limits and complemented the centralistic main food supply system. Next to socialized farms, there were already millions of private farms providing secondary incomes during the Soviet era (state limitation: private production area of 0.25–1 ha, two cows with calves, a pig with piglets, ten sheep, unlimited poultry).

This legal situation had the result that despite high technical innovation and planning in the main production farms, 'historical', mainly subsistence production conditions including the necessary technical knowledge have persisted in the private second-income farms. Such a privately-owned small farm was also quite normal in peripheral hilly and mountainous regions during Soviet times. A consequence of the extensive breakdown of the centralistic supply system was the necessary (re)extension of private production systems, particularly in these areas. The key shortage factors are the increasingly low availability of vehicles and machines, which is also a consequence of the extremely low investment level, and the lack of chemicals (mineral fertilizers, pesticides). And not least, the current land use situation also has psychological reasons: even when financial support is available, it is only very rarely invested in long-term agricultural projects. The uncertainty over the future development of agriculture is too large and other investments (e.g., infrastructure, communal facilities and social 'networks') appear to have gained more importance.

In this context, livestock keeping is achieving an increasingly important role. It requires no great investment, with the exception perhaps of the outdated Soviet-age stalls; it has traditional roots (persisting from Soviet times largely in private ownership); it is more flexible than crop cultivation with regard to land use, requiring less machinery; finally, it fills particularly sensitive supply shortages (e.g., milk, 'luxury' meat products).

Investigation Area IA 1

This investigation area has been for a long time, despite socialization, continuously characterized by a small farm, peasant-type mixed agriculture. At present, subsistence farming is the predominant form. Almost every household possesses a cow and some poultry. Horses are important as draught animals. Some households own goats, but not pigs. Compared with UG 2, the proportion of grazed land (herded grazing, cut pastures, arable-cut pasture complexes, in some parts, woodlands) is consequently much higher (Table 7.5). Mineral fertilizers are applied sporadically and only on arable fields. Plant protection chemicals may at most play a marginal role.

Table 7.5.
Area proportions of land use in the investigation area 1. As the slope of the area in not considered because of the absence of a digital height model, the area data are given as approximation values. [a] Grassland without a definite use designation (water meadow, temporary fallow land, mixed use etc.)

Type of use	Area (km²; rounded)	Percentage of total (%)
Wood	7.26	37.2
Arable-mowed pasture-complex	2.90	14.9
Herded pasture	2.12	10.9
Mowed pasture	2.07	10.6
Settlement	1.75	9.0
Field woody vegetation	1.49	7.7
Grassland (not investigated)[a]	1.14	5.8
Water areas (Dnister and lakes)	0.39	2.0
Fruit cultivation	0.35	1.8
Total area	19.51	100

As a rule, the cattle in the whole investigation area are kept in a system of herded pasturing in communal pastures. In the central town of Busovesko, the proportion of agricultural land used as pasture has risen continuously in the last few decades because even in Soviet times, the state provision of animal products was inadequate. The local sovkhoz (cooperative) was dismantled in 1993. Herded grazing areas and mowed pastures form more or less continuous strips below the woodland along the sides of the valley. There are currently no meadows in the area which are not used for grazing. Because the stock levels of the farmers are mainly low, the animals are frequently communally taken to the pastures. The current land use is comparably small-scale and is characterized by a high proportion of grassland (Fig. 7.16).

Investigation Area IA 2

In line with the primary need for an increase in productivity, mineral fertilizers were regularly applied to pastureland during the Soviet era. The keeping system consisted at least partly of rotation pastures used in cycles of 2–3 days.

Even today, the pastures in this area are used relatively intensively. The degree of bush encroachment on the pastures is very low. The grazing regime includes forest pastures. From an economic point of view, however, livestock keeping is rather secondary and it is generally agreed that this is limited to areas where arable use is not permitted because of difficulties in working the soil or a lack of machinery. With respect to the latter reason, arable land is currently ploughed mainly using horse teams. While it appears that there is no tradition of communal pasturing, the animals from each farm are independently led onto the pastures. There are no meadows. Animal feed is produced as in earlier times on large feedstuff fields. In the last 25 years, considerable areas have been afforested (mainly on former pasturelands). This may well be a significant contribution to the very high grazing pressure currently affecting the remaining pastures. Overall, however, livestock keeping plays more of a secondary role (Table 7.6).

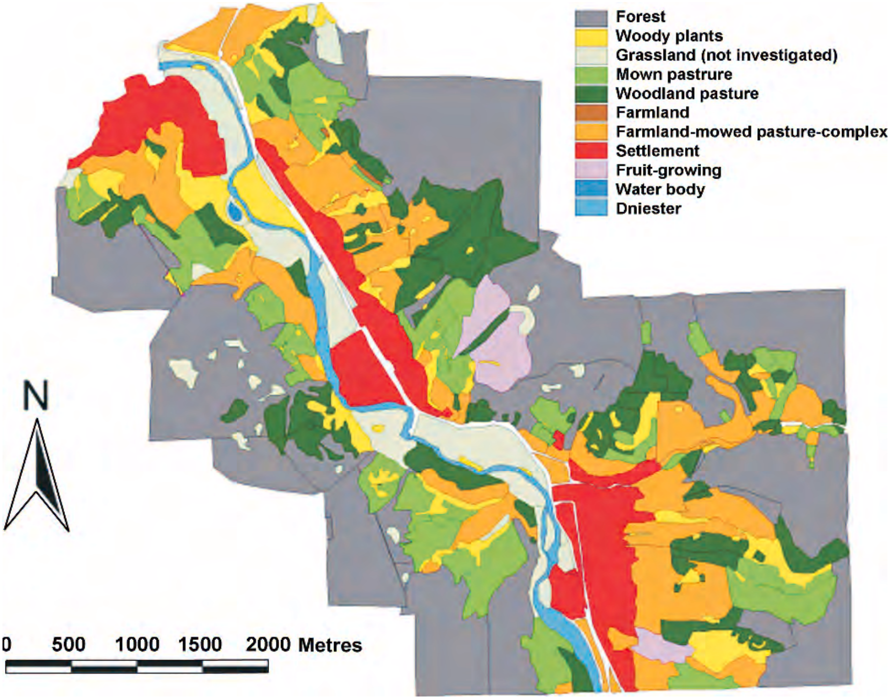

Fig. 7.16. Land use in 1999 in IA 1. Basis: Topographical map 1:10 000, site mapping, user interviews. The arable-mowed pasture complex makes up 14.9% of the area, herded pastures 10.9% and the mowed pastures 16.6% (from Satzger 2002)

Table 7.6. Overview of the data collected in 2000 for the villages Koropetz, Vystra and Gorigljadi in IA 2 (*ha:* hectare; [a] in former times, Gorigljadi owned large areas of the opposite bank, including pastureland along the bank and woodland on the slopes)

	Koropetz	Vystra	Gorigljadi
Total area (ha)	3 452	?	872
Wood (ha)	844	–	? (earlier 300 ha)[a]
Arable (ha)	1 683	377	498
Pastureland (ha)	460	66	60.5[a]
Private land (ha)	580	?	198
State land (ha)	1 804	?	?
Collective land (ha)	1 068	?	331
Cattle (inc. calves)			
Private	~800	~250	350
Collective	50	180	90
Development in the collective farms	Strong decrease	Until 1992 350 cows and about 300 calves in collective farms	
Main farming system	3-field-rotation without fallow (potatoes, cereal, feedstuffs)		

7.3.4
Grazing Management of Cattle

Interviews with 21 cattle herders were used to collect information about stock levels and the grazing regime in IA 1. According to this, in Busowesko and Werchnej Luschok in 1991, there was a stock level of at least 313 cattle. The actual number was very probably much higher. The main breeds were Fleckvieh and Original Black Pied (dual-purpose breeds), as well as crosses. The cattle herds on individual pastures were usually comprised of animals from several farms. About 70% of the herds had not more than 20 animals. Of 18 herds, 8 had less than 11 cattle, 5 less than 20 and 2 less than 30 cattle. This indicates that communal keeping systems were undertaken only in a limited form and hardly at community level but rather at family group level. This is supported by the interview results (Table 7.7, question 7) which show that for a high proportion of herders, there were clearly no arrangements with others. The keeping regime was very uniform: even the milk cows were consistently driven out twice a day (question 8), the first and last drives in the year were highly synchronized and dependent on the weather conditions. There were no winter pastures: clearly, they were not necessary because of sufficient stall feed (from meadows and feed cultivation). There was no custom of keeping sheep flocks. Goats and the keeping of mixed livestock hardly played a role.

There is a diffuse perception of the herders with respect to the changes during the previous decades (Table 7.7, questions 9 and 10). No clear trends can be derived here. However, it is clear from the statements of 15 out of 19 herders that specific pastures are grazed less than they were a short time ago. With increasing cattle numbers, this can only mean that the grazing pressure has clearly risen on other pastures. The two reasons given most frequently for the reduced grazing of individual pastures were: (1) that on these pastures, too many disturbing bushes were growing there, and (2) that when the cattle grazed on the less-grazed pastures, they did not eat much and gave less milk. These findings could be connected with the recognized tendency that currently, grazeable areas in the landscape can in no way be seen as a limiting factor, and a minimization of effort is achieved by simply 'giving up' pastures and woodland edges thickly overgrown with bushes because of the large amount of work needed for the restoration to more productive pastures.

Even so, pasture management is accepted as absolutely necessary, although there appears to be no uniform 'technology'. Key to achieving proper care of pastures is seen as the reduction of woody vegetation growth, although different methods are used for this (question 20).

7.3.5
Historical Development

The historical land use in IA 1 is significantly different from the current use. There are very detailed land register records in the area for the year 1896. According to these, the main part of the land surrounding the community Busovesko, including a large part of the valley side, was used for arable farming over 100 years ago (Fig. 7.17a). Compared with the current situation, pastures took up only a small part of the land. The proportion of enclosed wooded areas has more than doubled since then, and the area adja-

Table 7.7. Selection of standardized questions (shortened), which were put to 21 cattle herders in IA 1. Further questions were only used in individual cases and served to specify the current land use on the map. [a] Deviation from *n* = 21 arises from no answer being given or a response that the question was not understood

Question	Alternatives	Number of answers[a]
1 How many cattle are there in your herd?	<5 6–10 11–20 21–30 31–40 41–50 >50	4 4 5 2 0 3 0
2 How many goats are taken along with the herd?	0 1 2	12 4 2
3 Same number of cattle each day?	Yes No	13 4
6 Do other herds graze the same area?	Yes No	5 14
7 Are there agreements with other herders?	Yes No	6 12
8 How often are the cattle driven out daily?	Once Twice	0 21
17 Same area grazed each day?	Yes No	11 10
9 Are there big changes in herds in recent years?	Yes No	10 8
10 Number of cattle increasing (only in case of 9 answered with 'yes')?	Yes No	8 2
11 Are individual areas much less grazed now?	Yes No	15 4
13 Why are these areas much less grazed?	To many bushes Cattle graze too little there Cattle don't like to graze there If cattle there too long, give less milk Area too steep	7 6 7 7 5
15 In which month are cattle first driven out?	April May	4 16
16 In which month are cattle last driven out?	October November Winter	10 10 0
20 Pasture care?	Burning of bushes and trees Damage bark Cut with ax Take goats along	7 5 13 2

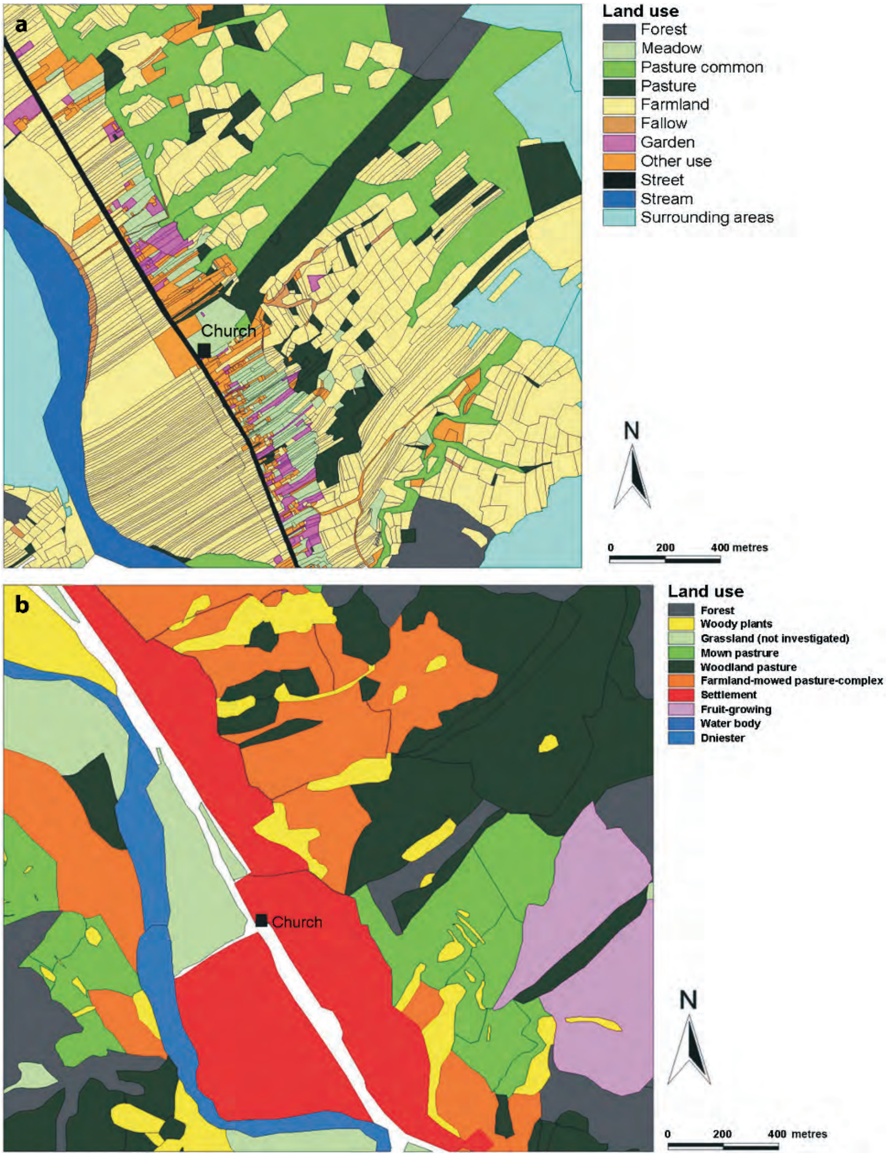

Fig. 7.17. Land use in the community of Busovesko/Ukraine (about 20 km²) **a** 1896 (source: map 'Busovesko in Galicia, 1896', 1:2 880); note the high proportion of arable land on steep slopes, and **b** 1999 (current use map, 1:10 000)

cent to settlements is currently 19% (Fig. 7.17b). The practice of planting crops on steep slopes, which are today used for grassland grazing, was usual during Soviet times in the 1950s. Old field terraces which are still recognizable in the grassland prove this point (Fig. 7.18).

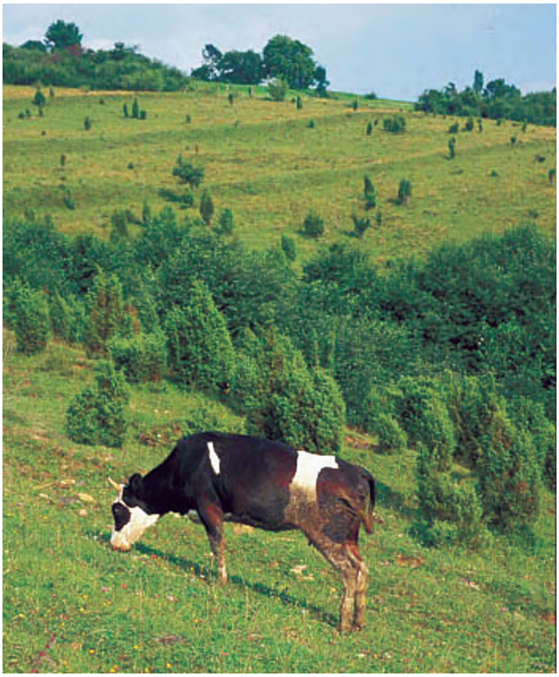

Fig. 7.18.
Cattle pasture east of Busovesko (East Carpathians) with old field terraces in the background (photo: H. Plachter)

7.3.6
Summary of Findings

In both of the investigation areas, herded grazing is the normal form of livestock keeping. Cattle keeping is predominant and sheep, pig and goats play a much smaller role, if at all present. There are, however, significant differences in detail between the two areas. In the Carpathian region of the upper Dnister (IA 1), the degree of communal work sharing and arrangements between the herders is higher than in the middle Dnister (IA 2). In addition, there are clear differences in fertilizer application to the pasturelands and stall-feeding of the livestock. While the 'modern' forms of livestock keeping are more closely followed in IA 2, probably not least because of the kolkhoz system of work, work variants have persisted in IA 1 which more closely resemble those of Central Europe in historical times. A lack of farming materials, including mineral fertilizer and machinery, has a greater effect on the form of livestock keeping in the mountain region. The keeping system is very similar to one practiced in some regions of western Central Europe only a few decades ago, known as 'Allmende', or commons grazing. The use dynamic of the pastures is a particular feature. In the course of a century, there were several shifts from predominant grassland use to a high level of arable farming and back again in IA 1. This also corresponds with the historical findings for western Central Europe (see field – grass – crop rotation; Beinlich and Plachter 1995; Konold 1996).

For the western part of Central Europe, the (re)introduction of forest pasturing for cattle is considered unrealistic (Fink et al. 1998; Riecken et al. 1997). Most authors suggest the establishment of anthropogenically dynamic systems in which cattle are kept at low densities in large paddocks. In this way, there would be only limited intrusion in the vegetation dynamic from management measures (e.g., Fink et al. 1998; Luick 1997; Oppermann and Luick 1999). The operation of a work force would in most cases be kept very low because of the associated costs. Because cattle tend to gather in groups or herds and develop preferred areas over time, keeping systems using large-scale paddocks would not require the presence of a herder so on parts of the paddock after several years, a relatively uninfluenced succession could become established which in no way would always be compatible with the objectives for these areas.

Herded keeping brings together two advantages: a moderate control of the livestock effect with a simultaneous partial preservation of the freedom of choice of the animal and the possibility of permanent (smaller) management intrusion from the herder, who is in any case present. It should be noted here that the extent of the required management intrusion in question increases exponentially with the lengthening of the intrusion interval. While very young growths of woody vegetation and herbaceous 'problem plants' can be easily dealt with manually, management measures at intervals of several years demand a huge effort, often producing only doubtful results, e.g., tangled blackthorn (*Prunus spinosa*) growths. This effect can also be observed on the pastures of IA 1: heavy bush encroachment of the pastures are not 'brought back' to a better condition but are avoided for future grazing. Herders show comparable behavior in central Georgia (Didebulidze and Plachter 2002). In addition, very frequent small intrusions are more favorable for the continuity of the habitat availability for many species than less frequent large intrusions.

It is clear that the control of the cattle herd by herders often leads to temporary overgrazing of some parts of the pasture. The selection of grazing land is done without any great organization but the involvement of the herder has the consequence that the largest part of the area is kept open in the long term. The extent to which fire is used to reduce growths of less nutritional plants resulting from undergrazing cannot be quantified for the investigation areas. Apart from several observations of individual fires, only a few herders mentioned the use of fire as a management control. A further human intrusion into the grassland of the forest-pasture landscape in the investigation area is the so-called 'Egartwirtschaft'. Areas used as pastureland over several years are temporarily used for arable farming (Opitz v. Boberfeld 1994). It can be assumed that through this type of rotation on overgrazed or undergrazed land, plant species have good possibilities to become re-established. The re-occurrence of the plant cover can result from persisting diaspore banks or seed dispersal over short distances. The application of fire and an Egartwirtschaft with similar measures could, admittedly, be carried out also in large paddocks without the constant attention of a herder.

In typical, intermeshed forest pasture landscapes, the habitats required by particular species are more or less found as isolated points spread over the whole landscape (cf. Elligsen 1997). The probability is therefore relatively high that sub-populations here will find themselves with achievable distances through active dispersion, compared to less intermeshed landscapes. For grazing systems without the controlling influence of herders, it can be assumed that the distances between the sub-populations will be larger than for traditional forest pasture systems because of the greater habitat mosaic created by the natural behavior of the cattle (e.g., increasing preference for open areas which have arisen from previous high grazing levels, clear boundaries between grazed land and woody vegetation edges because of a preference for the latter for grazing).

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7.4
Socio-Economic Structure of a Central Georgian Grazing System

Benjamin Haerdle · Andrea Bontjer

7.4.1
Outline Conditions

The landscapes in Georgia have changed fundamentally since the break-up of the Soviet Union and independence in 1990 (Didebulize 1997; UNDP 1998). During the Soviet era, the export of high-value products such as citrus fruits, tobacco and tea was an important economic activity (Nakani 1998); today, the supply of the Georgian population with basic foods is the main priority. However, as there is a lack of infrastructure, fertilizers, plant protection chemicals, machines and fuel as well as no up-to-date agricultural policy, the yields are not sufficient and family subsistence economy is becoming increasingly more important for the supply of food to the public (Kegel 1997).

Between 1990 and 2000 in Georgia, a form of agriculture has become established which may well have many characteristics in common with those of Central Europe in historical times, with respect to both structure and the effects on nature. The features of this include the minimal significance of nutrients and pesticides (Didebulidze and Plachter 2002), food provision without financial benefit, a return to labor-intensive procedures through low wages, the formation of local work communities (communal livestock keeping, common grazings) and maximized use of natural productivity, particularly in the area of livestock keeping, through various systems using different livestock species.

Consequently, an analysis of the current livestock keeping practices in Georgia can suggest important indicators which have influenced Central European pasturelands over the centuries, and help to understand how this could have led to the high biodiversity which we now observe there.

The study presented here analyses the technology and the socio-economic background of largely subsistent cattle keeping using the example of a village community north of the capital Tbilisi.

7.4.2
Development of the Cattle Stocks and Keeping Systems in Georgia since 1990

Since 1990, there has been a big reduction in cattle numbers in Georgia (Didebulidze and Plachter 2002). This is a consequence of the situation in the large state livestock centers, which could not import enough feedstuff after 1990 and therefore had to sell or slaughter the stocks. In the meantime, the keeping of domestic livestock is very largely privatized.

During the Soviet era, some regions were clearly overgrazed and others were hardly grazed at all. Since then, the effects of grazing have spread over the land. In addition, the traditional transhumance keeping systems have largely broken down with the consequence that many pastures are no longer stocked throughout the year. Through the staggered use of different livestock varieties, (above all, cattle, sheep and pigs), a ubiquitous grazing impact has arisen which also affects most of the woodland ecosystems.

The number of cattle has steadily risen since the middle of the 1990s, as a result of the family subsistence economy. Today, almost every farming family owns one or two cows in order to provide milk, yoghurt and cheese for themselves and to sell surpluses in the markets or along the roads (Kegel 1997).

During the days, the animals graze with herders present on pastures near the villages and return to the stalls at night. In many cases, herds are supervised by paid herders or the owners, who drive the cattle onto the pastures and bring them back at night. In any case, the pastures are use communally as common grazing land (Narimanidze 1998). All areas are grazed which are accessible, including woods and harvested arable land. There are no fenced paddocks. This traditional form of grazing was also common in Central Europe until industrialization.

7.4.3
Methodology

Investigation Area Sages

In an area about 30 km north of the Georgian capital Tbilisi (Tiflis), the grazing system practiced there (herded cattle keeping) was investigated (see Chap. 3). The area was particularly suitable because of the easily delineated grazing areas on an isolated so-called 'Zeugenberg' – a foothill of the Great Caucasus.

The community of Sages consists of about 1 000 inhabitants and was formed in 1926 with the building of a hydro-electric power station. Most of the occupants are (former) workers from the power station and other local industries and establishments. As well as a small group of high-rise apartments, single-family houses with gardens dominate. There is no traditional farm agriculture with arable crops although there was always some private animal keeping and horticulture. Both of these have increased since the granting of independence and the changed economic conditions since the breakdown of the markets.

The 150 ha pasture area is located at a height of between 500–700 m and is strongly reliefed. It is characterized by a century-old zoo-anthropogenic usage and shows a mosaic structure of bush formations, intensively used grassland, meager areas and woodland (see Sect. 6.4). The area comes under the administration of the Saguramo Forestry Department, which at the time of the investigation charged the owners a symbolic rent of €0.5 each year per head of cattle.

Socio-Economic Analysis

The investigations were carried out in the period from May to September 1999. The use of interviews was selected for the collection of data relevant to grazing. Standardized interviews (30 herders and livestock owners) were carried out with the help of translators. For this purpose, a 'herders' questionnaire with 30 questions and an 'owners' questionnaire with 18 questions were prepared. A closed form of questions was selected (multiple-choice questions, Schnell et al. 1999) which offered an easy and effective evaluation and helped to avoid translation losses and lengthy translation sequences. The questionnaires contained questions about the interviewee (age, sex, education etc.) but most questions focused on the cattle keeping (development of the numbers since 1990, expected future growth), the grazing regime and the care of the pastures, as well as the economic importance of cattle keeping for providing the family with food.

7.4.4
Results

Keeping Forms

During the period of the investigation, the Zeugenberg was used as a common pasture by two herded cattle herds with a total of 130 animals. Herd 1 consisted of on average 84 animals. This number fluctuated between 80 and 100 animals according to season, feed availability and the sale and purchase of cattle and calves. There were 46 cattle in herd 2 and the numbers fluctuated between 40 and 50. The majority of the animals were adult females. For each herd, an adult bull and varying numbers of older calves were brought along – the younger calves remained in stalls in the village or as soon as they can eat grass, are taken in same-age groups to graze nearby accompanied by a herder.

Because no consideration was given to breeding or the maintenance of pure breeds, it is difficult to assign the individual animals to any particular breed. They were probably mixes of Black Pied and local breeds such as the Chewsuren cattle, a small and light Georgian breed. All of the animals come from the local community of Sages. They belong to different families, each family possessing on average two cattle.

The grazing was organized as all-year station herded keeping: during the day, the animals are on the pastures and at night, they remain in the village stalls where they are milked mornings and evenings. Each herd is led by two herders. Every morning at about 8:00, they leave the village, returning at about 8:00 in the evening. The care of the cattle is organized so that each owner takes a turn at herding once or twice a month. For each herd, the assignment of this work is done by a responsible person who draws up a monthly rota. At short intervals, the herders are alternated through a rotation procedure (see below).

The two herds have ‘standard routes’ to avoid an overlapping of their ways to the pastures. The routes are changed to varying degrees in accordance with the habits of the herders, the season, the availability of feed and the weather conditions. In the interviews ($n = 30$), 60% of the herders said they used the same routes and areas every day while the remaining 40% said that they varied their grazing regime. If there were feed shortages in summer or winter, one of the two herds were taken to areas along the river Mtkvari near the village. This could also be observed during the investigation period. In July and August, herd 1 was by the river almost every day. At the end of August, the feed situation in the investigation area improved following rainfall and the herd were taken there regularly again.

The livestock density on the unfertilized pastures amounted to on average 0.4 LSU ha^{-1} calculated over 365 days, and a strong space-time stochasticity of the grazing pressure is recognizable (see Sect. 6.4). The areas of the investigation are currently neither fertilized nor otherwise managed. Although half of the interviewees indicated that they found the presence of bushes disturbing, these were not removed. Reasons given for this were mainly to do with the lack of responsibility for pasture management: “Not my job”, “Waiting for the instruction”, “Not allowed because the land belongs to the Forestry Department”, “Difficult to organize”, “No interest”. All of these were mentioned as a reason.

The investigation area is grazed the whole year round. The animals remain in the stall and are fed hay only if the ground is covered by an unbroken layer of snow. However, this is the case on only a few days each year. Otherwise, no feedstuffs are brought in as the families cannot afford the cost of purchase. The hay in the post-grazed pastures to the east of the plateau is not available to the animals because the lands belong to other communities. Only a post-grazing is tolerated.

Socio-Economic Aspects

Cattle keeping in the community of Sages is closely connected to the economic crisis which has affected Georgia since independence. Half of the interviewees were unemployed and when one considers that also many of those in employment, above all state employees, received no wages or only very low wages, one can assume that most of those questioned had no regular income. This underlines the importance of cattle keeping as a way of providing for the family.

In 1990, the majority of the current cattle owners (18 of 30) did not have any cattle and 22 of the 30 families have increased the stock numbers. In total, there has been a 61% growth since 1990. For almost 70% of the interviewees, economic reasons are given as the main cause of this increase in cattle numbers.

There has been a corresponding increase in the importance of cattle numbers for the maintenance of the family: while retrospectively for 1990, 70% of the cattle owners characterize the significance of cattle as "unimportant" or "secondary", in 1999, 83% consider the function of their own cattle as "important" or "very important" (Table 7.8).

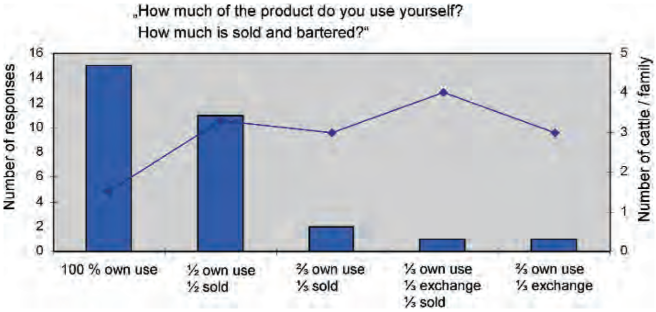
The main function of the cattle is the supply to the family of milk products, especially yoghurt and cheese. Half of those questioned said that 100% of the produce was for their own use, and for these families, the average number of cattle owned was very low at 1.7 per family. Cattle ownership rises to an average of 3.3 per family when half of the product is sold, as is the case for 37% of the families (Fig. 7.19).

The milk output of the cattle is very low because of the lack of protein-rich feed – at most, only 3–4 liters per day ($\mathrm{l\,d^{-1}}$). In addition, the family's own garden is used for their own food supply with the cultivation of fruit and vegetables. 90% of the cattle

Table 7.8.
Significance of the family's own cattle stock comparing 1990 to 1999 in the investigation area, based on standardized questions (*n* = 30)

Assessment	1990	1999
Unimportant	18	0
Secondary	3	5
Important	4	8
Very important	5	17

Fig. 7.19.
Data from 30 cattle owners about the use of the products (*bars*) in relation to the average number of cattle per family (*points*)



owners said that they owned their land, with the average area amounting to 1 738 m^2. More than 92% of the landowners use the complete area of their garden to grow agricultural products while only two of those questioned worked just part of the land.

Almost half of the cattle owners would increase their cattle stocks in the case of a persistently poor economic situation. 63% of the herders do not consider the animal feed capacity of the area as overstretched. However, an economic improvement would cause half of the current cattle owners to completely give up cattle keeping in the future.

Among the 30 herders, there were only two who were 'professional' – the rest had learned other professions and had taken up cattle herding because of unemployment or for a second income. In spite of this, 60% of the interviewees said that they derived pleasure from their occasional work as cattle herder. The average duration of years as a cattle herder was 5, ranging from less than a year up to 34 years. Cattle herding was mainly an occupation of men, there being only one woman in the thirty.

7.4.5
Discussion

The socio-economic situation in Georgia is typical for the countries of Eastern Europe which are undergoing transformation (cf. Jaksch et al. 1996). The ending of production in large areas of industry following the breakdown of the Soviet Union also affected the investigated community of Sages, founded as it was on industrial output, with respect to the creation of a 'secondary economy'. As a reaction to the high unemployment around the capital city of officially nearly 35% (UNDP 1998) – for the interviewees, as high as 50% – a system of subsistence livestock keeping was introduced. The information given by the cattle owners about the rise in cattle numbers since 1990 corresponds to the general situation in Georgia (Kegel 1997; Didibulidze 1997). The markedly strong increase of 60% is a consequence of the industrial character of this more urban-style residential area.

Cattle keeping in the investigation area offers the population a low-cost and simple way to provide for themselves. Even though the animals need to be looked after over the whole day, cattle keeping for individual owners is not work intensive as each one is assigned herding duties only once or twice a month. Through agreement between the herders and owners, the work of herding is carried out smoothly. There are rules in the area, for example, covering the line of boundaries and rights of use on cut pastures, as defined by Ostrom (1994) for common property regimes and 'Allmende institutions'. Climatically favorable conditions make grazing possible throughout the year, although a lower productivity (low milk yields, forced slaughter in winter because of feed shortages) has to be accepted. In order to guarantee a profitable land use, the average milk yield in Georgia must be increased from the present 1 000 l per cow per year to 3 000 l (Didebulidze 1997). This could be achieved through selective breeding, fertilizer applications, a lower stocking density or the use of concentrated feed. However, the measures are not feasible under the present conditions. On the contrary, the number of animals will increase further with the continuation of the poor economic situation, irrespective of the capacity of the pasturelands. According to the interview statements, should there be a significant improvement in the economic conditions, many of the cattle owners would rather give up grazing over the long run than see the introduction of intensification measures.

The current situation in the investigation area is very similar to the conditions in the German low mountains from the 18th century to the start of the 20th century (Bruckhaus 1988): the grazed areas are in both cases on steep, rather bare ground, grazed by the village herds as community pastures. The grazing rights for the better grasslands were also restricted at that time in Central Europe to grazing on mowed meadows and the hay harvest belonged to the actual owner. Similarly, there was year-round grazing which included woodland and fallow areas. Arable land was often fenced to keep free-roaming cattle away (Beinlich and Manderbach 1995), something which is also observed in Georgia today. As in Germany in the past, fertilizers are not used on pasturelands. There was and is a continuous nutrient transfer from pastures to the resting places and above all, to the village (stall dung is spread on the gardens). Today as in the past, the yield from cattle keeping is hardly sufficient for self-provision.

A lack of farming materials has been substituted, as in historical times in Central Europe, with communal rules on the management of livestock keeping. The main limiting production factor is the shortage of nutrients. Over-use extending to land degradation is, quite consciously, seen as an acceptable risk.

Acknowledgments

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7.5
Development of the Grazing System in the South Black Forest during the 19th and 20th Centuries

Stefan Kostrzewa

7.5.1
Introduction

A significant characteristic of the South Black Forest (Baden-Württemberg) was the communal pasturing, mainly in the form of common grazings. In the second half of the nineteenth century, and particularly in the twentieth century, there were fundamental changes to the systems of land use, especially with respect to grazing (Geiger 1990; Mohr and Schröder 1997; Schwendemann and Müller 1980). However, about 10 000 ha of these common grazings have remained in existence to the present day (Luick 1997; Pohle 1986) and are used communally for young cattle in paddocks with a relatively low stocking density. These common grazings are considered by some authors as exemplary areas representing 'semi-open pasture landscape' (Luick 1996a,b, 1997). For the formation of future large-scale grazing systems (Conradi and Krüger 1999; Conradi and Plachter 2001), an analysis of the functioning of these communal grazings (today often supplemented with 'visiting' animals) can make a significant contribution.

The work presented here documents the historical development of the grazing systems and the operating conditions of a typical landscape in the South Black Forest in the course of the nineteenth and twentieth centuries. In addition, of particular interest is the analysis of the regulating system of communal grazing, which often had and still has quite varying effects on the land in the form of 'secondary uses'. The individual historical development of each pastureland plays a decisive role with respect to their present qualities and finally, with respect to the current levels of flora and fauna.

7.5.2
Methodology

Location of the Investigation Area

The historical analyses were carried out in an area of landscape comprising 3 422.3 ha in the South Black Forest east of the Todtnau–Schönau axis in the Wiese River valley. The areas considered were the present-day districts of Präg (1 177.4 ha), Tunau (415.6 ha) and Geschwend (1 086.1 ha), as well as the area of elevated woodland between the districts (743.2 ha) which belongs to the administration of Schönau in the Black Forest (Fig. 7.20). The historical analysis of the communal grazing system of this region of the South Black Forest concentrates mainly on the changes in land use, stock numbers and 'secondary uses' with respect to cattle keeping. Very heterogeneous data sources and data qualities are available which require different processing and evaluation methods.

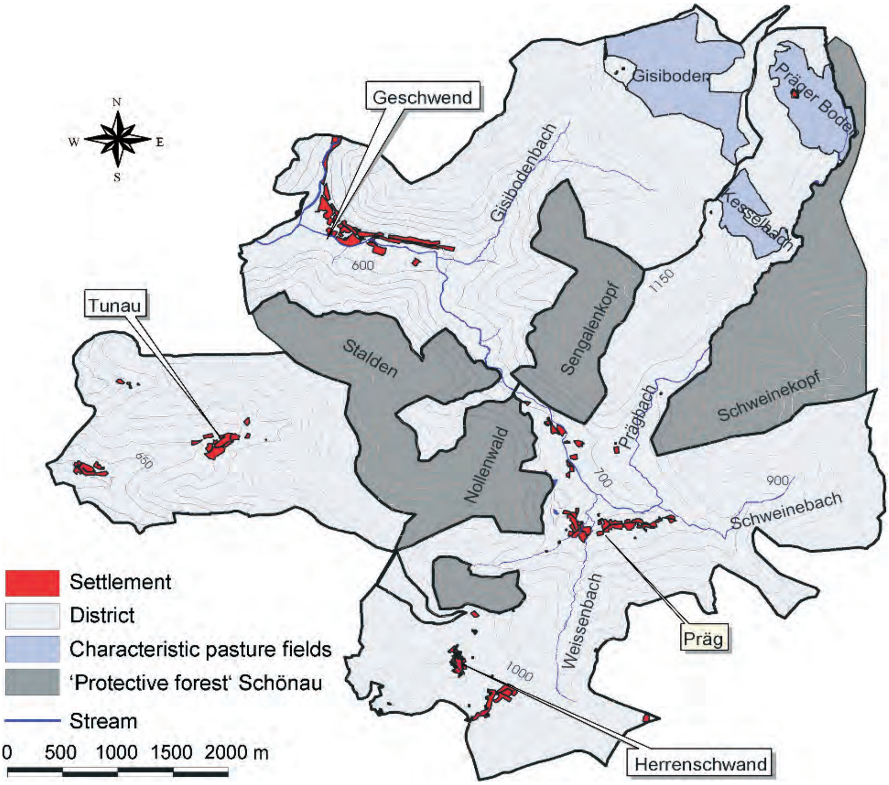

Fig. 7.20. Districts of Präg, Tunau and Geschwend as well as the 'Schönau Forest' in the South Black Forest in the year 2002. To allow a better orientation, characteristic elevations and current cattle pastures in the region are shown

Historical Maps and Aerial Photography Material

The development of land use in the investigated regions covering the period 1800–2002 was analyzed using maps and aerial photographs. The aerial photographs were digitized in GIS (ArcView 3.2), equalized and geo-referenced. The best basic information for the current situation of land use was available from a series of aerial photographs taken in 1996/1997, as well as from elevation surveys carried out by the author during 2000–2002. The resolution and quality of the material declines over past time. However, aerial photographs taken in 1986, 1976 and 1951 could be comparatively evaluated. There are no aerial photographs covering the investigation area for the time before the Second World War so it was necessary to resort to very heterogeneous mapping materials for this period. The main problem with this old material is the varying resolutions and the use of different, inconsistent legends. From the year 1922, topographic maps with the scale 1:25 000 are available which could be complemented with other local historical data sources (work plans, fertilizer plans, livestock weights, stock lists from the state pasture inspectorate from Schönau, see below). Neither the topographical maps of the Grand Duchy of Baden 1846 (scale 1:50 000) nor the Schmitt map of south-west Germany in 1797 (scale 1:57 600) were able to provide additional information.

However, with a combination of aerial photographs and map material, it is relatively easy to investigate the current and historical division of land use types, as well as the area proportions over the landscape. From the latest data levels (aerial photographs), the following land use types could be distinguished: meadow, sparse orchard, young cattle pasture, dairy cow pasture, other pastures (goat, sheep and horse), bush encroachment, woodland, settlements and traffic ways. This division could be maintained as long as aerial photograph material was available (1951) or the aforementioned complementary information was present, that is, going back to 1922. With older sources, the keeping of different livestock species cannot be distinguished, so the summarizing description of 'pasture' is used for this period of time. However, these 'pastures' are largely to be equated with cattle keeping, which dominated the region throughout the investigated period (1800–2002) (see Geiger 1990; Mohr and Schröder 1997; Schwendtmann and Müller 1980).

Where the maps of the Grand Duchy of Baden from 1846 differentiate various grassland use types such as meadow and pasture, the Schmitt map of south-west Germany in 1797 only differentiates between woodland and open land. Therefore, the differentiations of open land in meadow and pasture zones from the more recent data level of 1846 were transferred to the corresponding earlier sources (provided the relevant areas were still open land). This process is plausible inasmuch as, on the one hand, the layout of land use, that is, the land use zoning, was clearly comparably stable in the region from the Middle Ages until at least the end of the nineteenth century (Eggers 1954, 1957; Götz 1929, 1936; Schwendtmann and Müller 1980), and on the other hand, expensively installed walls, ways and hedges (with fruit trees and the like) created a separation of use into meadow zones (meadow and field grassland) and pasture zones. In the course of this almost 50-year period, there would likely have been little or no change. A differentiation within the meadow zone into arable and meadow use is however, not possible here.

Livestock Levels

The analysis of the livestock levels over the course of the last 200 years is based on the archives of the state pasture inspectorate in Schönau, Black Forest. In the past, cattle stocks were recorded precisely in the form of 'stocking lists' and 'weight lists' under the control of this inspectorate. The calculation of the stocking levels is worked out using the current standard (dairy cow = factor 1; young cattle = 0.6; goat/sheep = 0.15; cf. Landwirtschaftskammer Nordrhein-Westfalen 2003). In addition, over the course of time, varying area boundaries are considered. Between the available historical points in time, (as a rough approximation) there was a continuous change, that is, the area was subject to a linear regression.

Grazing Management

Functioning communal grazings in this area required a lot of additional work over a large area, which is summarized in the following as 'pasture management'. For the analysis of such efforts with respect to communal livestock keeping forms such as common grazings, the 'work and fertilizer application plans' of the state pasture inspectorate in Schönau were drawn upon. These contain lists of all the 'work services', that is, services in return for cattle pasturing. Parallel to this, a monetary 'grazing tax' was raised. Today, this tax pays for a pasture manager who carries out pasture management on behalf of the commons users, which is correspondingly recorded in the work plans of the pasture inspectorate. Thereby, over a small area (5–10%), so-called 'machine hours' are recorded which are multiplied by a factor of five for the evaluation of service rendered compared to manual pasture management in order to take into account the time or work savings of machines against manual efforts. The category 'miscellaneous' was an additional yearly entry, but only sporadic, recorded activities such as pasture inspections and cattle weighing, or minor works to pasture lodges or cattle grids are assigned to this.

What was earlier described as 'work services', of which the equivalent is today carried out by a pasture manager, has been complemented since the early 1990s with a 14-head work team using two mulching machines (state pasture inspectorate, Schönau). Each year, the work team and mulching equipment take care of the management of woody vegetation and 'problem weeds' on about 400 ha of land. However, their activities are recorded in a heterogeneous form in the records of the pasture inspectorate – for the work team, as hectares cleared (without working time!) and for the mulcher, the number of hours in operation (with no reference to area covered!). In order to compare this data with earlier work hours, the following conversion algorithm is necessary: both work team and mulcher can operate on an average of ~130 working days from May to October, from which holidays, sick leave and breakdown and maintenance of the machine can realistically be seen as amounting to a maximum of 100 working/operating days. In total, the work team and mulcher work ~400 ha of pastureland each season. The mulcher is used to control bracken, 'weeds' and young woody growths, and depending on the site and extent of bush growth, covers about 1 ha area/day (Martin 2002, pers. communication). For the assumed 100 operating days for the two mulchers, then, 200 ha can be treated. The remaining 200 ha, affected by thicker and older woody growths, has to be manually worked by the work team. For the 100 working days referred to, at 8 h d^{-1}, a total of 11 200 working hours are achieved by the 14-man team. This means that the work team needs on average 56 man-hours for a 1 ha area. For the work services given in the work plans of the teams therefore, an equivalent of 56 work hours per hectare was assumed.

This manual work compares with the 8 operational hours per day of the mulcher, which likewise works 1 ha d^{-1}. An operational hour of the mulcher is therefore (56/8) 7 man-hours equivalent. The recorded operational hours of the mulcher was therefore multiplied by a factor of 7 to allow comparison with earlier, manual efforts. The parallel work output of the pasture manage has also been recorded in hectares since the 1990s, and the same conversion (1 ha = 56 work hours) was carried out. Other activities of the pasture manager have been represented since 1990 in itemized numbers (hours per year (h yr^{-1}) for the particular activity). To convert these to work hours, correction values from the past have been derived (water trough = 40 h, cattle grid = 40 h, spring water accessing = 60 h, attaching drinking bowls = 10 h) as hardly any time saving can be achieved with technical applications for these mainly manual tasks.

7.5.3
Results

Development of Land Use, 1800–2002

The pattern of land use around the year 1800 was fundamentally different from what we see today in the three investigated districts. The lower valleys (e.g., from north-east to south-west, Fig. 7.21) were mainly used as meadows, but were in part covered by trees and therefore not yet developed agriculturally. From here, cleared forest ways (to the east of the area) spread over the slopes and connected the farmed areas via high plateaus (east and north-east of the area). Several hill areas were also not yet developed agriculturally (south and in the center of the area) and were covered with large, connected woodlands. New forest routes were oriented mainly to side streams of the large valleys. The clearings used as pastures were located mainly close to the settlements, for example, around Tunau. In this way, also steeper slopes near settlements were used as pastures, as in the north of Geschwend and west of Präg. Because of the

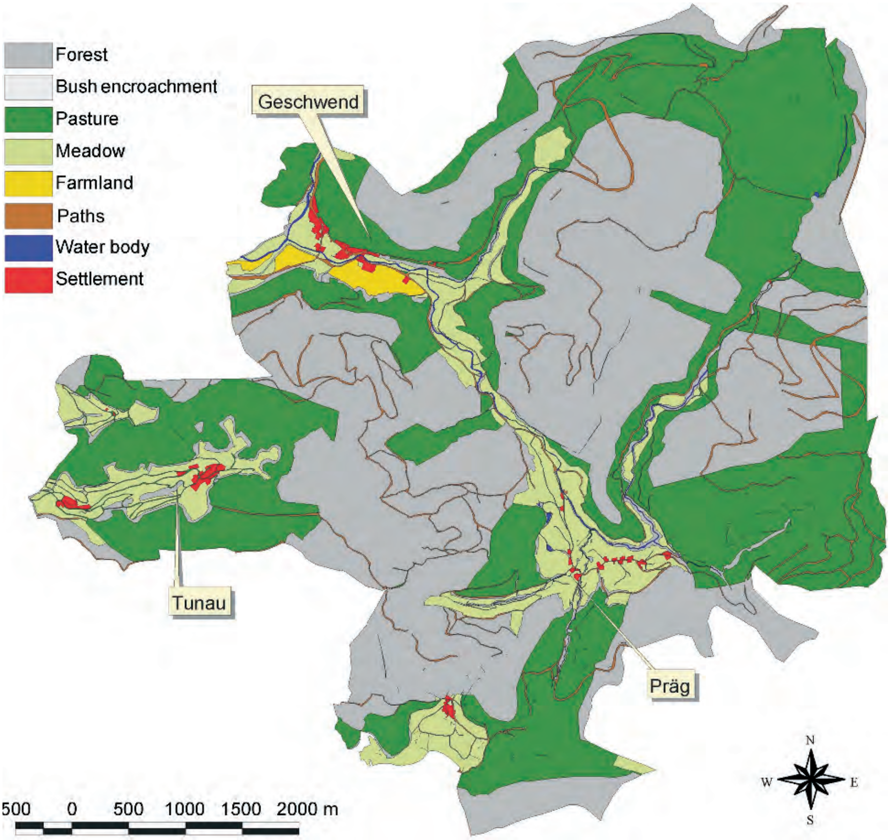

Fig. 7.21. Land use distribution in the year 1797, in the (current) districts of Präg, Geschwend and Tunau

orientation of use along valleys and close to settlements, there were no characteristic 'pasture fields' around the year 1800. Over the whole area, pastures cover about 40% of the land, compared with 10% meadows and woodland making up about 48% (Table 7.9). In the lower, climatically favorable locations at Geschwend (~600 m a.s.l.), there was a small amount of arable farming. Settlements and traffic routes represent only a small part of the current level.

In the course of the next almost 50 years, major changes to land use took place. Large areas of steep unfavorable slopes were taken out of use and left to succession (e.g., north-east of Präg and round Geschwend, Fig. 7.22). According to the time of the particular agricultural task, bushy zones are recognizable in 1846 or have been cleared again (cf. east in Figs. 7.21 and 7.22). Parallel to the farming activity on steep locations near settlements, other more distant areas were cleared and newly developed as pastureland (south of Präg, north-east of the area, north-east of Geschwend). In part, this resulted in new open-land connections being created, for example a high moor on a hill location between the three districts. On the other hand, farming activity caused previously accessible pasture strips to be cut off (in the north-east of the area).

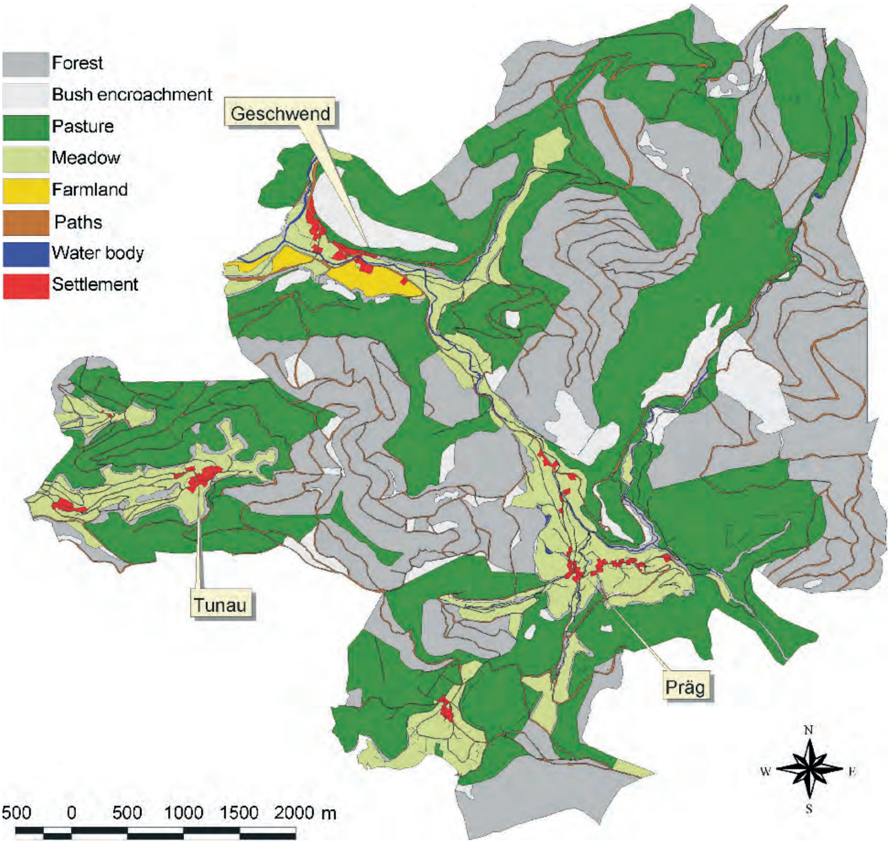

Fig. 7.22. Land use distribution in the year 1846 in the (current) districts Präg, Geschwend and Tunau

In the middle of the nineteenth century, parallel agricultural activities and the development of new farming areas had created the now characteristic pasturelands of the region as spatially connected complexes of individual pastures. Parallel to this, the current administrative units of the area were set up and the island-like woods of the 'Schönau Forest' lying in the center of the area arose, with their characteristic 'protective forest' features and in part straight-line boundaries between wood and open land. The proportion of woodland decreased in the first half of the nineteenth century by about 4%, while the pastureland increased by about 2% and the meadows were extended because of the increased need for hay and feed. Also, new meadows lying far from the settlements were newly developed, for example, to the east of Geschwend or south of Präg. The area of arable land remained constant in the first half of the nineteenth century while settlement areas and routes increased slightly.

The pattern of land use described here remained more or less unchanged until the 1920s (Fig. 7.23). The use of the open land decreased to a level comparable with the year 1997 (Table 7.9). The affected areas included meadows in peripheral locations, such as north-east of Geschwend. Also, the formation of meadow islands distant from the

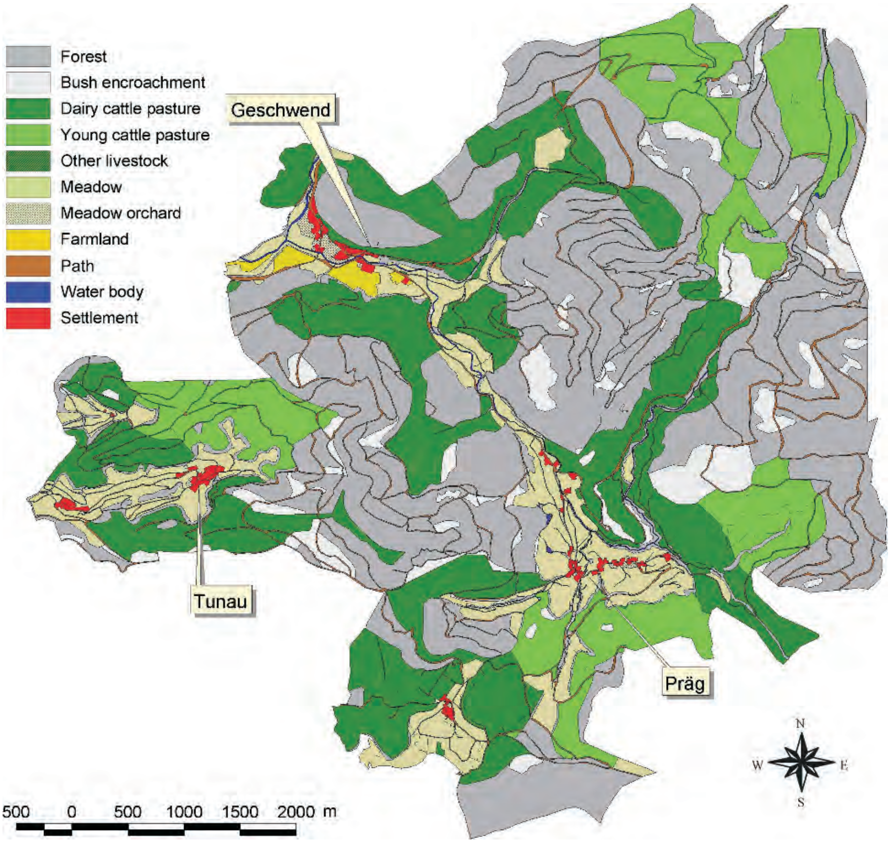

Fig. 7.23. Land use distribution in 1922 in the (current) districts Präg, Geschwend and Tunau

settlements continued apace. In part, pasture strips were cut off, for example, along water ways north-east of Präg and Geschwend. Until at least the 1920s, there was a relatively stable form of land use in the region. In the valley locations, meadows and arable fields were used. This belt of meadowland was sharply separated from pastures by hedges, walls, and terraces with ways.

Among the historical map material, the topographical map of the year 1922 is the first to be of sufficient resolution and exactness to enable the boundaries to be understood in detail, for example around the village of Tunau (Fig. 7.23). In addition, the topographical map 25 from 1922 and complementary material make it possible for the first time to differentiate information about young cattle and dairy cow keeping. Dairy cow pastures were located in easily accessible places near towns. The young cattle were kept further away on hills or steeper slopes. Stretching out from Präg and Geschwend are dairy cattle pastures, for example, connected to the meadow zone of the valleys in a north-east direction. Separated by more or less impenetrable lines of wood, the young cattle are located on hills and upper slopes distant from the settlements.

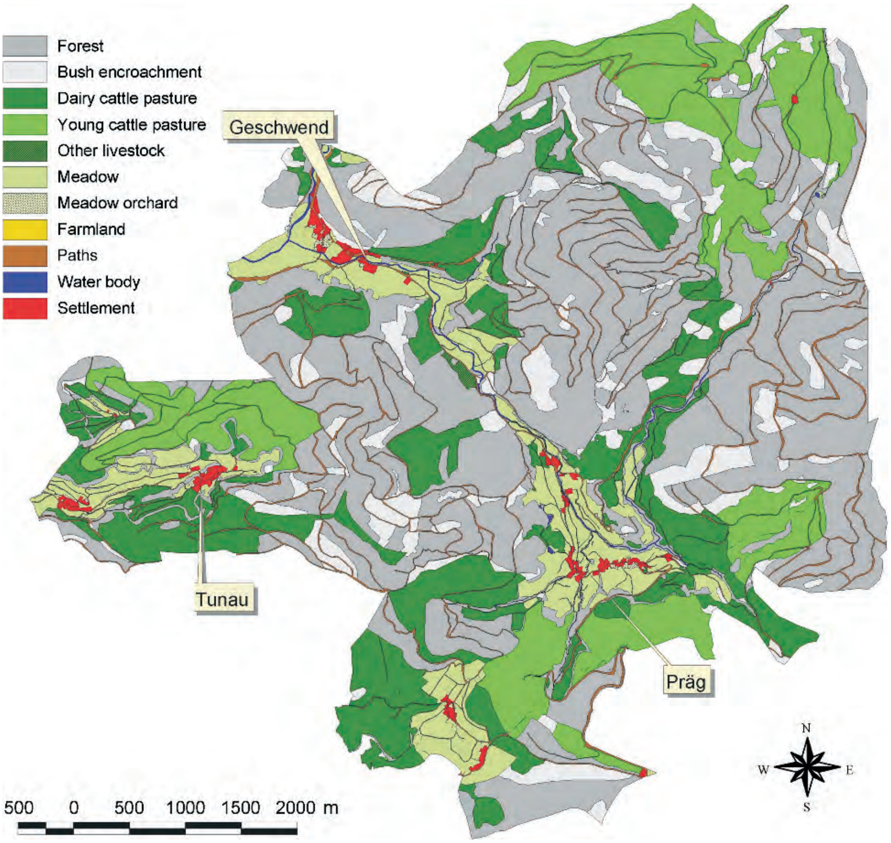

Fig. 7.24. Land use distribution in 1951 in the (current) districts Präg, Geschwend and Tunau

Until the middle of the twentieth century, there was a further decrease in the area of agricultural open land. In 1951, woodland formed more than half of the investigated district areas for the first time with about 54%. With respect to abandoned use, meadows were just as much affected as pastures. Pastures lost a proportion of about 5% of the investigated area between 1922 and 1951, of which mainly dairy cow pastures were affected. The main losses to succession were for dairy cow pastures located at medium to long distances from the settlements, and strips of pasture and open land were again cut off (north-east of Präg and Geschwend, Fig. 7.24). Although dairy cattle still played a dominant role, the proportion changed slowly in favor of young cattle in comparison to the year 1922. Through this change in agriculture, the hitherto stable system of use which had started in the middle of the twentieth century began to blur. The previously strict separation into meadow and pasture zones along a clear boundary was no longer absolute. Livestock keeping was moved to lower locations and encroached the previous meadow zones. The remaining arable land of the investigation area around Geschwend changed completely to meadow use.

The fundamental changes to the land use system of the South Black Forest continued through the following 25 years until the middle of the 1970s. There was a further

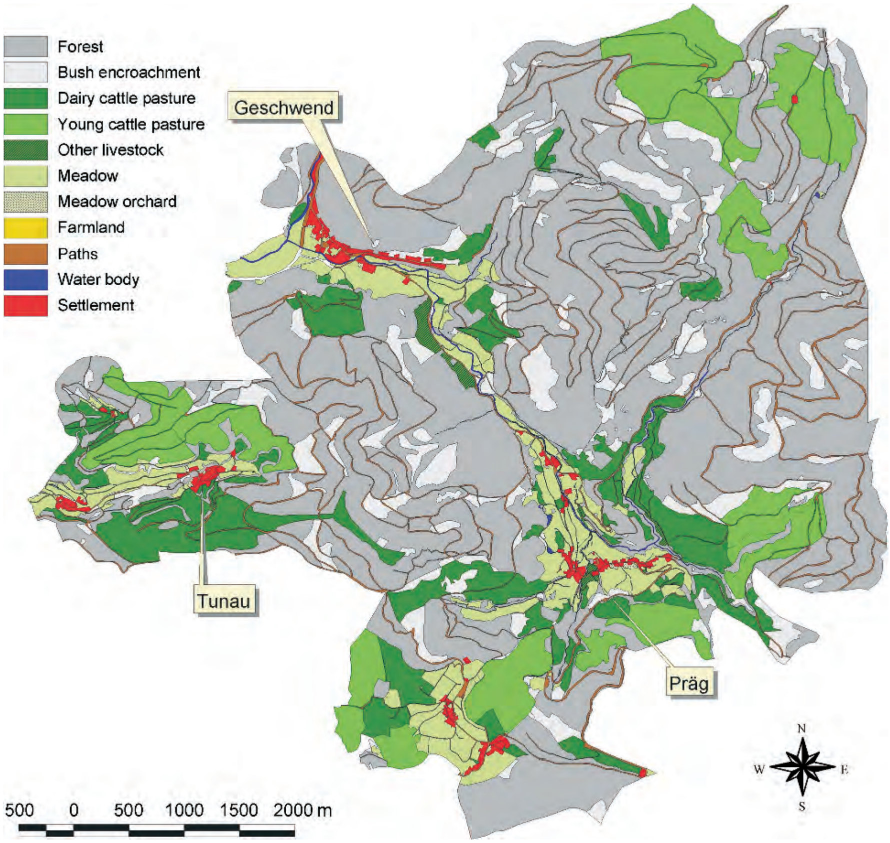

Fig. 7.25. Land use distribution in 1976 in the (current) districts Präg, Geschwend and Tunau

dramatic reduction in dairy cow numbers, while young cattle were only slightly affected. The proportion of pastureland reduced by almost 10% in only 25 years and the area of woodland increased by the same amount. Whole areas of land such as along the water ways north-east of Präg and Geschwend or in the center of the area were no longer grazed, or grazed only in small areas (Fig. 7.25). The decrease in above all, peripheral meadows continued until 1976. In addition, mowed fields were replaced with pasturing, also in the previous meadow belt, meaning that the once strict zoning system disappeared further (e.g., round Präg). Other meadows in the valleys were taken out of use, so that in 1976 for the first time, there was no longer a grassland connection between Präg and Geschwend. In the decades after the second world war, there was an increase in areas covered by traffic routes and particularly by settlements.

Until the middle of the 1980s, this trend continued uninterrupted. The area of open land used for agriculture reduced further by 4%. The area of wooded land and bush-covered land increased by the same amount. Again, it was particularly dairy farming that saw a decline in the last peripheral areas, for example, east of Tunau (Fig. 7.26). Apart from some sporadic goat keeping, there was no longer any open land between

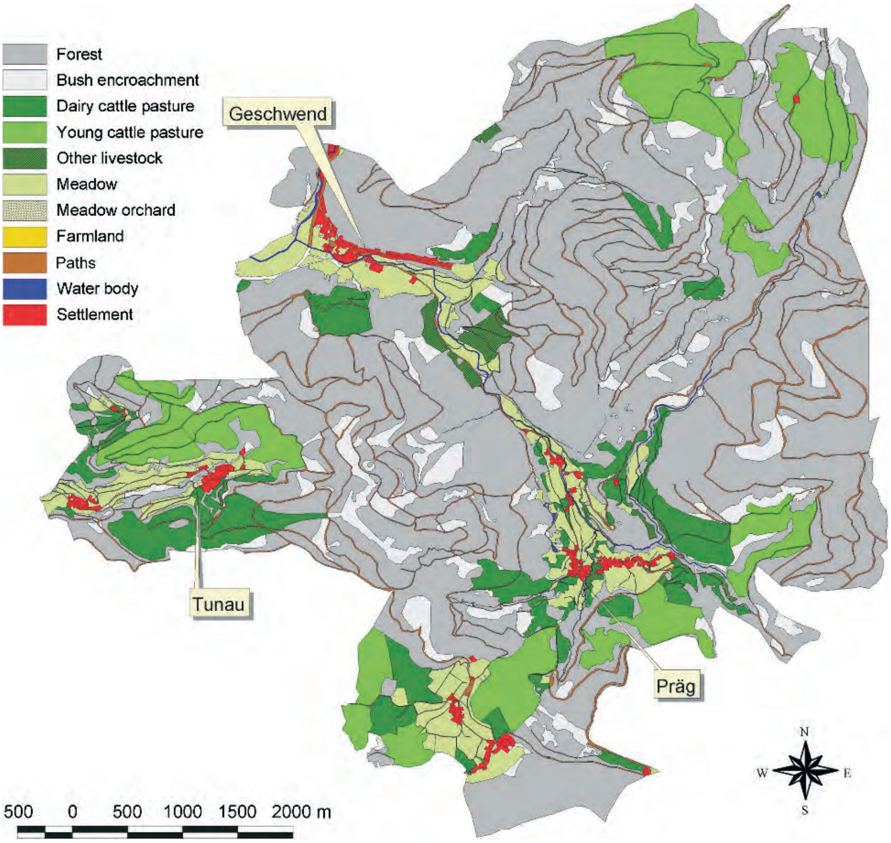

Fig. 7.26. Land use distribution in the year 1986 in the (current) districts Präg, Geschwend and Tunau

Table 7.9. Land use changes in the districts Präg, Geschwend and Tunau, 1797–2002. [a] Methodically not separable

Land use form	1797	1846	1922	1951	1976	1986	2002
Arable	0.7	0.7	0.5	0.0	0.0	0.0	0.0
Meadow	9.3	10.0	9.6	8.3	7.1	6.5	6.4
Sparse orchard	0.2	0.2	0.2	0.1	0.1	0.0	0.0
Pasture, of which	39.3	41.0	36.7	31.5	22.0	18.7	16.9
dairy cow pasture	[a]	[a]	23.4	17.6	10.0	7.5	6.2
young cattle pasture	[a]	[a]	13.3	13.9	12.0	11.2	10.7
other livestock	[a]	[a]	[a]	[a]	0.4	0.8	0.8
Woodland	47.7	43.9	48.3	54.1	64.1	67.5	69.3
of which bush	–	5.6	5.7	9.3	8.9	7.5	3.7
Settlements	0.5	0.6	0.7	0.8	1.0	1.1	1.1
Ways	2.2	3.1	3.7	4.2	4.8	4.9	5.0
Water ways	0.4	0.4	0.4	0.4	0.4	0.4	0.4

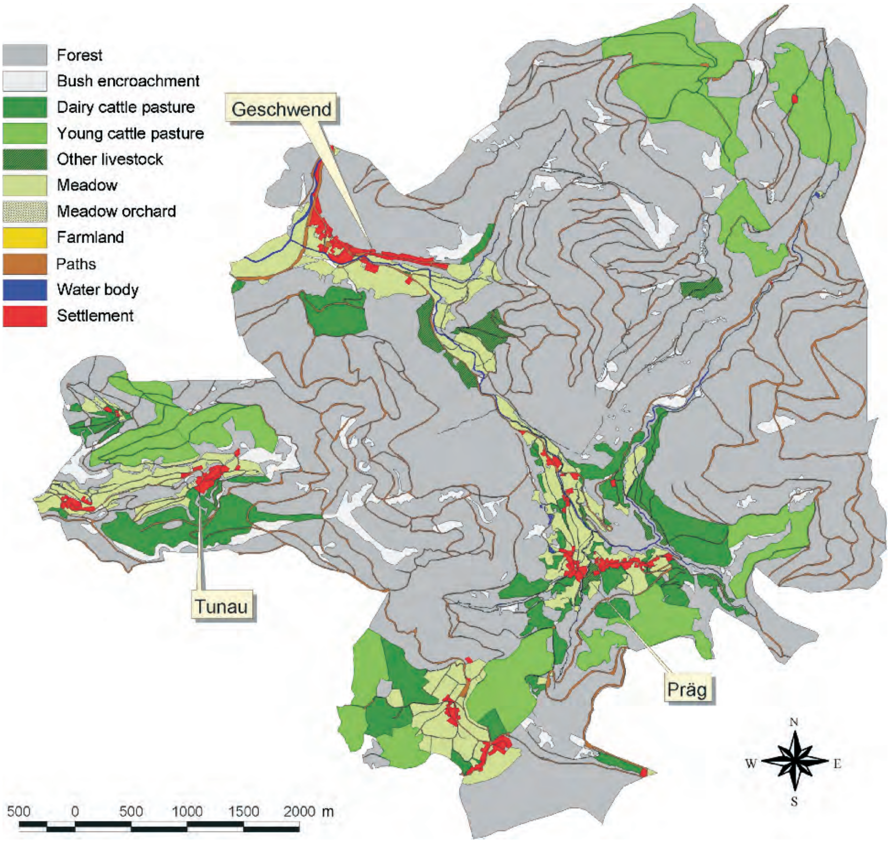

Fig. 7.27. Land use distribution in the year 2002 in the (current) districts Präg, Geschwend and Tunau

the towns of Präg and Geschwend and their (young cattle) high pastures to the north-east. The breeding of young cattle took on a considerably greater significance than milk production and in places (in Tunau) there was an increase in cattle numbers.

This development trend of the second half of the twentieth century has continued until the present, although with diminished speed. In the period between 1986 and 2002 the proportion of open land again decreased by 2% while woodland increased by the same amount. In comparison to the previous period of time, the withdrawal of agriculture has slowed down. In 2002, there are still fragments of the former clearly marked use zones to be found.

Detailed Analysis of Livestock Keeping, 1930–2002

The loss of open land described here, particularly that of pastureland in the twentieth century, can be put down to different reasons. On the one hand, the number of farms in the investigated districts decreased drastically in the course of the twentieth century. Today, there are less than half as many cattle keepers compared to the turn of the last century. On the other hand, the stock numbers for the investigated period decreased quite considerably. As the example of Tunau shows, according to the community statistics, in the year 1880, 226 cattle were taken to pasture and in 1930, only slightly less with 204 cattle. Since the middle of the 1930s, the time when the stock numbers were first yearly recorded by the state pasture inspectorate in Schönau, the number of cattle in Tunau has reduced from 130–140 animals to the present number of about 80 (Fig. 7.28).

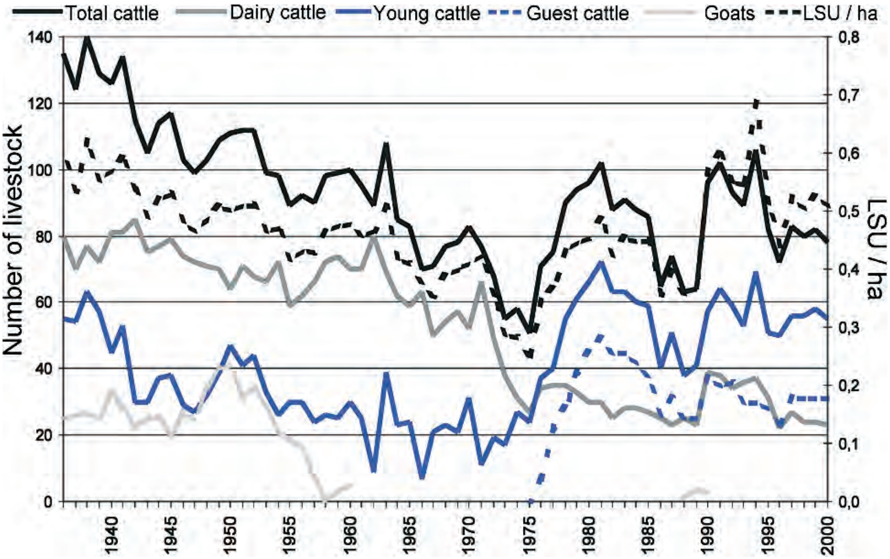

Fig. 7.28. Development of cattle numbers in the Tunau district, 1936–2000. Data based on: yearly stock lists recorded by the state pasture inspectorate in Schönau. Data for visiting livestock are proportions of the number of young animals. For the calculation of the stocking density (LSU ha^{-1}), the size of the pasture was assessed with GIS from historical maps and aerial pictures and a linear regression of the area between the available data was drawn

However, the type of cattle keeping has also changed fundamentally. The previously dominant dairy sector began to collapse in the 1970s and by the end of that decade had reduced by more than a half compared to 1930. As a reaction to this, in the following years, farming with young cattle increased and included a growing number of 'visiting' cattle, that is, the grazing of cattle from outside the region. In this way, the mix of breeds changed from almost exclusively native Hinterwald cattle to various modern highly productive breeds (Black Pied, German Simmental etc.) As a consequence, the breeding of cattle is today significantly more successful with average daily weight gains of ~800 g per animal, compared to the daily rate of only 500–600 g at the end of the 1970s.

In addition, the livestock numbers in the region in the first half of the twentieth century were significantly higher also because of the keeping of other livestock breeds. By the end of the 1950s, in Tunau, goats in not inconsiderable numbers were driven out with cattle in mixed herds. Added to this, in other districts (e.g., Präg), sheep were kept, although they never became established in great numbers.

The total livestock numbers for the region have therefore decreased greatly in the course of the twentieth century, meaning that less and less pastureland was needed. Additionally, the move from dairy to young cattle also meant a reduced requirement for animal feed and therefore for land, because of the reducing milk output and the lower ages and weights of the animals. Through both of these factors, the area of grazing land continued to decline during the course of the twentieth century.

Because of the gradual reduction of the pasturelands, the grazing intensity remained relatively constant at ~0.5–0.6 LSU ha^{-1}. Based on the older but less detailed Tunau community statistics with respect to livestock numbers of a ratio of 2:1 for dairy cattle to young cattle (cf. earliest data in Fig. 7.28), one can assume somewhat higher grazing intensities for the time before: 0.86 LSU ha^{-1} for 1930 and even 0.96 LSU ha^{-1} for the year 1880.

Grazing Management under the Common Grazings System and Their Dynamic in the Twentieth Century

Each user of the community common grazings system who brought an animal there had to perform a so-called work service – an activity for the improvement of the pastures – and/or pay a grazing fee. The extent of this work service was based on the number of grazing cattle. The work affected the pasturelands as a 'pasture management' measure to a high degree. This management work was also affected by the major changes in the land use system within the South Black Forest area in the twentieth century. The volume of the corresponding work services sank in both absolute terms and also in relation to the parallel reduction in the grazing area. Where during the 1950s, 4–12 h ha^{-1} yr^{-1} were carried out doing pasture care in the investigated districts, by the end of the 1980s this had reduced to about 2–6 h ha^{-1} (despite a parallel reduction in the pasture area). This is mainly because of the reduced number of cattle owners and with this, the reduced participation in the common grazings system.

The work services of the 14-man landscape management team, operating in the investigation area since 1987 with two mulching machines under the control of the state pasture inspectorate Schönau, has remained fairly constant within the scope of

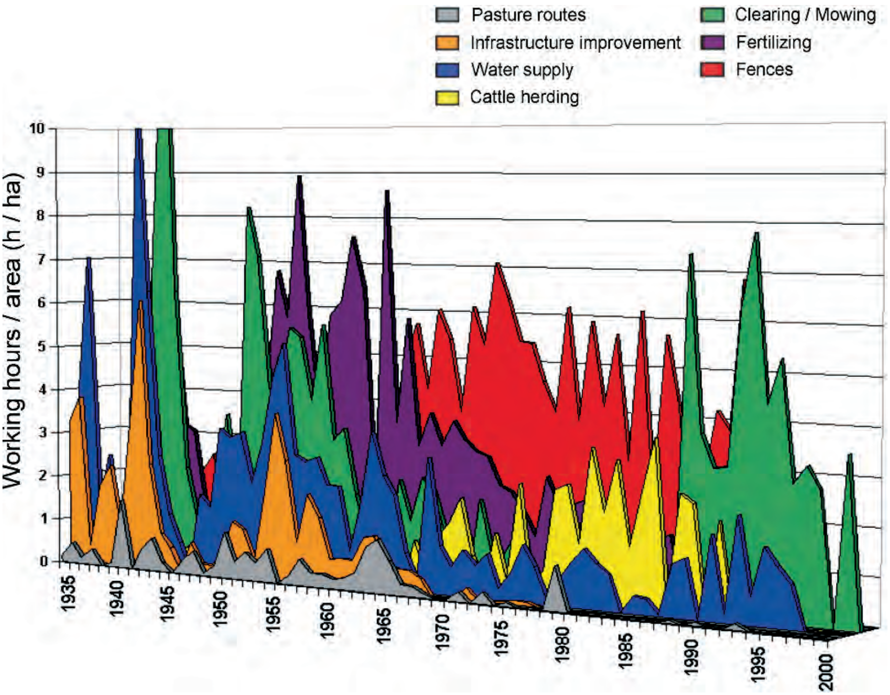

Fig. 7.29. Average yearly area-related work times within the common grazings in Präg, Tunau and Geschwend, 1934–2000. Individual activities based on work plans (source: State Pasture Inspectorate Schönau) are summarized into categories: structure improvements (deadwood collecting/burning, mound leveling, stone clearing, cow pat spreading), water supply (drinking places maintenance, water supply and drainage), cattle management (herding, rounding up), bush clearing (weed cutting, bracken cutting, mowing and haymaking, tree-felling), fences (E-fence maintenance, fence maintenance), fertilizer application, slurry and manure spreading). Miscellaneous is not shown. Since 1997, tasks have been recorded and calculated differently and supplemented with a landscape work team

the hours performed over the 15 years to 2001. Not just the volume of work reduced, however, but also the type and content of the activities over the course of the twentieth century reduced quite considerably. In the first half of the twentieth century, the available work capacity was mainly used to improve the infrastructure and vegetation structure. As well as access route building, drainage and water supply tasks were undertaken, the latter using troughs, the re-routing of water ways, pumps and pipework (Fig. 7.29). Additionally, much work went into the felling/cutting of woody vegetation and so-called problem plants (bracken, brambles, dwarf shrubs). But also, agricultural 'structural improvements' to the pastures were undertaken through measures such as 'stone clearing', 'deadwood collecting/burning', 'cow pat spreading' and 'mound leveling'.

These types of measures were also important in the 1950s and 1960s, although fertilizer application grew in significance (Fig. 7.29). Until the middle of the twentieth century, stall manure or slurry was spread on private meadows and only seldom on the community pastures, but this changed with the improved availability of artificial fertilizers at the beginning of the 1950s. At the same time, the amount of time spent on bush-clearing and removal of so-called 'problem plants' decreased. Until the middle of the 1960s, time spent on cattle managing did not constitute a great part of the work service within the common grazings system (although herding work was also done outside the system and is therefore not systematically recorded, for example, 'herd boys' from the local village).

Earlier work measures had a direct and (easily recognizable) benefit for the pasture or were of immediate use to the local population. For example, cleared bush or cut vegetation had an immediate 'additional use' in that it could be used by farmer or for personal use. Also, the spreading or removal of cow pats had a synergistic benefit for the pasture or land, on which a portion would be later spread. Additionally, the earlier mechanical measures, bush-clearing and cutting, even fertilizer spreading, had a direct effect on the land and the vegetation and spatial structure, and this was recognized by the individual farmers.

At the end of the 1960s, the move from herded keeping to paddocks with electric fences brought in a drastic change in the work system and also to the estimation of the individual work stages. For the majority of the activities to maintain the pastures, there was no longer any immediate clear benefit to be derived. Particularly because of the large amount of work needed for the newly introduced electric fences (which likewise had no 'use', other than to contain the animals on the pasture), all other tasks were greatly phased down during the 1960s and 1970s (Fig. 7.29). Only fertilizer application continued to be carried out on a comparable level. Cattle management increased significantly because of the move to the paddock system. This trend continued undiminished in the 1980s, while bush-clearing/cutting was almost completely left out so that by the end of the 1980s, the previous stewardship measures had changed over with large gains almost completely to technical maintenance. The measures carried out by the landscape work team could not prevent that from these activities, there was as a rule no direct value creation for the farm.

7.5.4
General Development Lines

The land use model in the investigated areas shows a long-term constancy typical for the region, that is, the use orientations have remained more or less homogeneous (cf. Eggers 1954; Geiger 1990; Götz 1929, 1936; Mohr and Schröder 1997; Reif and Katzmeier 1986; Schwendemann and Müller 1980). This constancy of the land use model in the South Black Forest has several causes. Firstly, community forms of grazing were already becoming established in more inaccessible locations, parallel to field rotation systems, by the time of medieval land occupations (Pohle 1986). Secondly, the predominant system of land division through inheritance brought about strict organizational forms. The system of communal grazing, mainly in the form of common grazings in the investigated areas, made the use of large connected areas viable and the development of high ground for grazing only then became possible (Müller 1980). In the investigated areas, the land use model of common grazings from the

Wiese Valley became established (Eggers 1954) although to the north of the area, this went over to the Breitnauer ley farming system (community grazing was abolished in 1750–1850, c.f. Eggers 1954) and in addition, varied through locally stricter limits on inheritance division.

The system of common grazings in the Wiese Valley is particular because of the low proportion of private possession, all of which was near to the so-called 'Zahmen Feld' (tame field); for each farmer there were 18–20 field parcels with a maximum area of ½ ha. This 'tame field' was subdivided into an inner zone of water meadows located at the bottom of the valley and without separation, and an outer zone further up consisting of field grassland which consisted of a 3–15 year arable cultivation and a 3–5 year meadow phase (Götz 1936). Through a clear boundary along walls, fences or trees, the so-called 'wild field' was connected on the upper slope side, subdivided into valley pasture and high pasture, both in community use.

Dairy cows were driven onto and off the valley pasture without any restriction on livestock density. The dairy herds were looked after by boys from the village (Schwendemann and Müller 1980). The high pastures, bounded by woodland edges or hedges from the valley pasture, often had the shapes of islands of tree clearance and were located on sloping or hilltop sites. The keeping of young cattle on the common grazings, limited to set numbers, was supervised by a professional herder during the whole grazing period, similar to the earlier alpine dairy farming.

In Präg, Tunau and Geschwend, the common grazings of the Wiese Valley remained unchanged with regionally typical land use divisions until the beginning/middle of the twentieth century, as other authors can prove for neighboring communities (Brückner 1980; Geiger 1990; Mohr and Schröder 1997). This constancy is a result not least of the fact that it was mainly subsistence farming that was carried out (livestock, crops) (Mohr and Schröder 1997) and with the exception of a modest trade in cattle, there was no outside connection (Luick 1997). In this way, through the geomorphology and administrative boundaries of the investigation area, the land use deviated slightly from the model described by Eggers (1954). A clear boundary between 'tame field' and 'wild field' was, for example, present in Tunau, albeit without any height zoning, because in the narrow valley, pastures for dairy cattle and young cattle were located on the opposite slopes. In Präg and Geschwend, this was achieved through height zoning with a complete boundary line between meadow and pasture.

Following industrialization in the first half of the nineteenth century, both the social structure and relationships within and outside the area changed and agricultural products were increasingly sold outside, resulting in an increase in demand for land (Schwendemann and Müller 1980), as is shown by the increase in open land between 1797–1846. Through improvements in infrastructure, in the second half of the nineteenth century, specific local products were no longer competitive as they could be obtained more cheaply from other places (Mohr and Schröder 1997). At the same time, new markets could be opened up, for example, because of the 'Höllentalbahn' (Hell Valley Railway), through which, according to Schwendemann and Müller (1980), the change to fresh milk production in stalls or valley locations was completed (methodologically not provable). Therefore, (according to Mohr and Schröder 1997), several (young cattle) high pastures were taken out of use, as is shown by the established decrease in pastureland in the district records (Table 7.9). Overall, the situation for farmers deteriorated drastically, leading to an abandonment of use, mainly of the high ground (Schwendemann and Müller 1980).

The second major trend in the second half of the nineteenth century was the greatly increased nutritional requirements of the growing populations (Mohr and Schröder 1997). This pressure, in combination with the changed trading conditions resulted in the decline of the old collective order, of compulsory rotation, cattle driving and way rights, and finally also of the three-field crop rotation system (Schwendemann and Müller 1980). This supported the self-initiative of individual farmers and led to land use intensification and with that, a lower need for land and abandonment of use (mainly of pastures) on slopes and hilltops.

On the other hand, the intensification of use led to devastation, particularly in the valley pastures and dairy cow pastures, where there was no cattle-driving regulation (Mohr and Schröder 1997). The stocking densities were very high, according to Schwendemann and Müller (1980) reaching ~1.8 LSU ha^{-1} in Bernau in 1890. The lower stocking density found in Tunau in 1880 of ~1 LSU ha^{-1} is possibly explained by the applied weight factor for young cattle (0.6). In the time between 1846 and 1922, the land use model of the common grazings in the Wiese Valley began to get blurred as the once stable system of land use zones became mixed.

In order to combat this devastation, the state pasture inspectorate Schönau and forerunner organizations coordinated measures after the end of the nineteenth century and beginning of the twentieth century to improve pasturelands. In this way, pasture orders and work service requirements were introduced to replace the hitherto unstructured and locally varying common grazings with an 'ordered', planned system of grazing. The former passiveness of the common grazings user was tackled (work service, work plans) and was tied actively to pasture stewardship. The work carried out in the framework of the work service order was the same, apart from a reduction in the first half of the twentieth century because of military service (Schwendemann and Müller 1980). Despite these efforts, the declining trend continued, particularly for pastureland in the first half of the twentieth century, as shown by findings in this work (–22.5%) and by the work of Eggers (1957) with –43% (1880–1955) for the whole of the South Black Forest. Additionally, the number of farmers and the hours worked in the common grazings declined in this period. Also, there was a further mixing of land use zones.

In the second half of the twentieth century, there was a fundamental structural and paradigm change in agriculture which showed up in the region mainly in the high number of support programs to 'resuscitate' a shrinking agricultural sector. The focus on 'additional activities' in the 1950s to 1970s, that is, on technical improvements, road building and fertilizer application, reflects the orientation of this program (for example, 'Black Forest Pastures Plan' 1959–1968, 'Black Forest Plan' 1969–1978). In this period, however, both the numbers of livestock and the numbers of farms declined, as is confirmed by Luick (1996a,b) for the administrative district Freiburg im Breisgau (1974–1994), with decreases of 55% for main activity farms and 41% for second activity farms.

The introduction of guest cattle herds could make no significant difference. The yield increases for young cattle breeding referred to earlier are a consequence of the new types of breed, which increased in numbers from the end of the 1970s, and not with the earlier use of paddocks at the end of the 1960s. Against this background, the published effectiveness of paddock keeping has to be viewed critically, as the increase in yield, at least in the currently relevant young cattle sector, is more a consequence of the growth of guest cattle keeping. Added to this is the certainly high (even now) amount of management of the cattle that is required, as the work analysis shows.

On the other hand, it is certain that earlier herding activities were assessed too favorably in the findings, as in part, they continued outside of the recording system. According to Geiger (1990), this came to more than the current efforts spent on herding the livestock. Other time-intensive 'additional uses' such as fertilising were at their most intensive during the period of the greatest loss of open land (1950s to 1970s), where the existing intensification and parallel tendency to abandon practices were driven forward. This can only be understood against the background of the agricultural policy of that time. It is therefore hard to understand why (chalk) fertilizer applications are still carried out today in the name of 'preservation management' (Geiger 1990), particularly when in the mean time, the maintenance of open landscapes is a central issue, such as is shown (Martin 2002 oral report; Pohle 1986) in the yearly rate of mechanical bush-clearing of 3–4% of the community pastureland in the investigation area.

The development of land use in the South Black Forest has in addition to the general agri-political trend, a regional characteristic. The fragments of the previous land use model (common grazings in the Wiese Valley) are clearly visible today (Fig. 7.28). Corresponding use zones more or less survive today, if not in the same places. Because of the described declining trends in agricultural use, the 'use zones', now not so clearly seen, are arranged more closely around the towns. In some areas today, young cattle pastures of the outermost zone lie on former dairy cow pastures. Because it was these dairy cow pastures which were the cause of the over-use and devastation in the nineteenth century, this displacement of the use zones may possibly be contributing to the present-day nutrient poverty of some young cattle pastures.

The effective additional uses of the common grazings system are also regional characteristics which (in changed form) have continued until today. As it could be shown, common grazing systems offer excellent possibilities of steering specific developments via systems of controls (Lenhard and Rodewald 2000; Seitz 1995).

In contrast to single-farm operations, nature conservation objectives could also be fairly simply achieved in this way, particularly if additional organizational structures such as the state pasture inspectorate are present. Provided that there is enough political will, the South Black Forest communal grazings could be seen as leading the way.

Then again, historical research into these land use systems, often described as 'traditional', show that in the past, they were anything but 'sustainable' as is currently understood, particularly with respect to the so-called additional uses and cattle densities. Only in this way could they generate the present-day nutrient deficiency and variety within the landscape. It is also questionable as to whether the system of common grazings, which are considered in their current form to be 'extensive' and which do not fully exploit the local capacities (cf. earlier stocking densities), are capable of producing such desirable conditions.

Acknowledgments

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7.6
Survey of Farmers in the Municipality of Ehrenberg (Hessian Rhoen)

Henning Holst · Klemens Karkow · Michael Rühs

7.6.1
Introduction

In consideration of the use of agricultural equipment, fertilizers and agricultural pesticides, the extensive cultivation of grasslands (cf. Greiner and Grosskopf 1990) contributes substantially to the attractiveness of the Rhoen landscapes. The varied scenery is distinguished by its small-scale structures. Here, agricultural activity represents a defining force with regard to the landscapes, cultural and social aspects of this area of low mountains.

In 2002, a survey of 21 farmers from the municipality of Ehrenberg in the Hessian Rhoen (Ulster Valley) was carried out with the purpose of providing information on the following subjects:

- analysis of the existing farming systems in the Rhoen, as well as their future viability
- insight into the individual work load and the economic situations of farms
- effects of changes in the system of agricultural support
- assessments of farmers on the possible and necessary changes in agriculture
- ascertainment of the level of satisfaction of farmers with the current situation and the future prospects

As part of the survey, the participants were given five conceivable agri-political scenarios (summarized in Table 7.10). At the time of the survey, the new structure of the EU agricultural policy had not yet been decided and even within expert circles, there was no knowledge of what was to come, as is described briefly in Sect. 8.1.7. The scenarios described are therefore based on the existing knowledge at that time.

This means that for this current work, which in Sect. 8.2 concerns the future of grassland use in the Rhoen, the scenarios given to the farmers cannot be taken without modification. It makes no sense in 2007 to discuss a scenario on ‘continuation of the agricultural policy which was abolished on January 01, 2005’. For this reason, the

Table 7.10. Summary of the scenarios

Scenario	Conditions
A Continuation of existing agricultural policy	Livestock premiums, compensation payments, agri-environmental program as in 2002
B Complete liberalisation	Abolishment of all farm subsidies, free world trade
C Big reduction in financial support	As in A, but 25% less support
D Payments for ecological improvements	Volume for environmental measures increases by 20%
E Production and marketing of premium food	As in B, but higher product price

scenarios A and C used in the survey are replaced in Sect. 8.2 with the scenario 'agricultural policy 2013'. However, the scenarios B, D and E from the survey are retained.

In spite of these changes, to which all scientific consideration of the agricultural system is exposed to, the results of the survey from 2002 remain of interest and have merit in linking with Sect. 8.2.

7.6.2
Methodology

The survey was carried out in the form of structured interviews (Jakob and Eirmbter 2000). All the relevant data relating to the farms were covered (including area farmed, type of farming, labor capacity, mechanization, labor demands for various activities). Furthermore, the attitude of the farmers to landscape management activities and future perspectives was included (landscape management, organic farming, farm succession and future under different scenarios).

The results allow for good qualitative statements on the current state of agriculture in the investigated area but do not permit an inductive-statistical evaluation. This is because of the nature of the spot sampling, with a relatively small number of farms and the concentration on the municipality of Ehrenberg. For the survey, farms were deliberately selected which still have a real perspective in agriculture: seven farms operated as a full-time farm (33%) and fourteen as part-time farm (including one 'hobby farm') (67%). In this way, the selection reflected the proportion of full-time and part-time farming (cf. HMULF 2003). With 862 ha, the 21 interviewees farm 40.5% of the agricultural land in the municipality of Ehrenberg.

7.6.3
Results

Land Use

Agriculture and the landscape in the municipality of Ehrenberg is characterized by cattle farming. It dominates the main production branches of suckler cow farming and milk production. The differences between the farms in the type of feeding (bullock fattening, baby-beef or heifer fattening) arise mainly from the meat sales potentials. Arable farming plays only a minor role in the region and continues to decline. Only one of the farms works more than five hectares of arable land. Many farms own small woodlands though these have no economic relevance. The interviewed farm managers are not in favor of an extension of the wooded area – they want to retain the open cultural landscape. The fields and pastures, which are hard to farm, are used almost completely and were recorded as permanent grassland.

Current Farming Situation

The agricultural structure of the municipality of Ehrenberg is characterized by relatively small farms. The average farm size is, according to the EU integrated administration and control system (InVeKoS), 19.5 ha and the average of the participating farms is 41 ha. The so-called growth threshold, under which in the course of structural change, the number of farms decreases and over which it increases, was 75 ha in Hesse in 2001 (cf. HMULF 2003). The average work force (WF) of the 21 participating farms was 2.4 workers per farm. Here, the 'work force' is a unit of measurement for the work carried out by a worker engaged in full agricultural employment and at maximum efficiency corresponding to their age. Most farms are financially not able to employ external workers so the work is largely carried out by family members. The grassland harvest is partly done in cooperation with other farms.

Most of the farm managers are relatively young. At the time of the survey (2002), 60% of the interviewed farm managers were between 30 and 45 years old. It is particularly the farmers whose farm activity is their primary employment who need a long-term economic perspective as outside the region there are few other employment opportunities. The nearest medium-sized town – Fulda – is about 40 km away and offers only limited possibilities of work.

Table 7.11 provides an overview of the main economic characteristics of the surveyed farms.

At the time of the survey, the farms received more or less the following support:

- compensation payment for disadvantaged areas of about €50 to €100 per hectare per year ($ha^{-1} yr^{-1}$),
- €300 per suckler cow per year,
- an additional €100 to €150, for nature conservation agreements, also €250 $ha^{-1} yr^{-1}$ as support for extensive grassland use.

The interviewees unanimously considered the current support as tight but sufficient. In agreement with the calculations from Sect. 8.1, they estimated the necessary minimum support contribution for the given product and factor prices at about €500 $ha^{-1} yr^{-1}$.

Future Prospects

With only one exception, the participating farms have been run by the same family for at least four generations. A developed awareness of tradition has meant that the rural population feel strongly connected to farming and their landscape. They consider its mainte-

Table 7.11. Factor inputs in the farms of the investigation area

Size (ha)	Number	kW/100 ha	Tractors/100 ha	Families WF[a]/100 ha	WF/100 ha, West Germany
> 50	7	136.4	4.3	3.1	2.2
20 – 50	6	224.4	8.2	6.8	4.2
10 – 20	5	380.6	14.4	12.2	6.3
< 10	3	348.2	17.4	30.4	15.7/9.3[b]

[a] WF = working force.

[b] First figure: farms of 2–5 ha, second figure: 5–10 ha. Source: BMVEL 2003, Table 56, p. 60. All other data is from the survey.

nance to be important and right, which is clearly seen in the strong participation in landscape management programs. 81% of the farms surveyed participate in the Hessian Landscape Stewardship Programme (HELP) and 95% in the Hessian Cultural Landscape Programme (HEKUL). In total, payments from these programs amount to only between 5% and 20% of the farm income for a little more than a quarter of the farms in the survey; a further quarter, however, receive more than 50% and for almost half, between 20% and 50% of the farm income. The concept of remuneration of ecological services is positively attested by about three-quarters of the surveyed farms and is unknown by less than 10%.

Also, the financial possibilities of ecological farming are largely seen as good. 13 of the farms (62%) see the development perspectives for ecological farming as positive. On the other hand, the farmers are very cautious about accepting fundamental landscape or structural changes such as those brought in by structural change and the EU agricultural policy.

The question concerning management succession was of key significance in the consideration of the future sustainability of individual farm enterprises as well as in the assessment of the dynamic of structural change in agriculture. Only two of the 21 farm managers questioned indicated that the farm succession already was assured in their case. For eleven of the farms, the question is still open. In most cases, the potential successor is still too young. Eight farm managers said that succession is not assured. For five of this last group, an abandonment of farming within the next one to five years is already decided. Four reasons were given for this decision to give up:

- There are insufficient economic prospects for the following generation, that is with respect to medium-term and long-term planning security.
- There is no farm successor on the farm.
- A continuation of farming requires too high investment costs.
- The local situation does not allow for a long-term continuation of farming because an expansion of the farm is hardly possible.

The unsecured farm succession is put down mainly to the low level of economic attractiveness and the lack of future prospects for farming in the Hessian Rhoen. The possibilities for an intensification of farming are very restricted, as is the case with opportunities to leave nowadays farm locations and build resettlements outside of the villages.

The Future of Farming under Different Scenarios

The five scenarios listed in Table 7.10 were shown to the farmers in the survey. They were asked to assess the effects of these on their own farms and on the continuation of agricultural activity within the next five to ten years. In each case, three variations of the possible reactions were offered: 'give up the farm', 'a slow exit' and 'livelihood assured'. The results are shown summarized in Table 7.12, with the exception of scenario E.

Scenario a: 'Continuation of the Current Agricultural Policy'

The financial support available in 2003 with reductions in direct payments of 2% is retained. Through modulation, there is a slight revaluation and expansion of agri-environmental financial support.

Table 7.12.
Future of farming under different scenarios, number of answers from farm manager ($N = 21$)

Future of the farm	Scenario			
	A	B	C	D
Livelihood assured	11	0	6	14
Slow exit	7	1	11	5
Give up farm	3	20	4	2
Considered farm expansion				
none	9	1	4	4
of 1–5 ha	3	0	1	3
of 6–15 ha	2	0	2	2
of 16–30 ha	1	0	0	1
of 30–50 ha	0	0	0	2
of > 50 ha	1	0	1	1
For giving up farm: interested parties?				
Lease	3	1	4	2
Purchase	1	0	0	0
No	0	19	0	0
For slow exit				
No change	3	0	3	4
Leasing/purchase of area	4	1	8	1
Development for assured livelihood				
Conventional intensification	3	0	1	0
Ecological intensification	3	0	2	2
Change to ecological farming	0	0	0	0
Extensification and more landscape care	5	0	3	12

Three farms would give up farming under the current conditions within the next three years. However, they are not certain about finding a lease-holder. Seven farm managers would then plan for a slow exit from farming. In most cases, they want to continue over another agri-environmental contract period (five years) before leaving. Only about half of those asked considered the viability of their farms assured. Of these eleven farms, three had settled on a conventional intensification strategy. These were dairy cow farms which had incurred a high fixed cost liability because of the installation of new cattle stables and were therefore less flexible. A further three farms wanted to intensify under organic production conditions (according to EU regulation 2092/1991). Five of those asked had decided on extensification and landscape stewardship under the current conditions.

Scenario B: 'Complete Liberalization'

Financial support is completely dismantled. Production is carried out at world market prices.

Judging from the results of the survey, the complete removal of subsidies would in the worst case cause a breakdown of farming across the Hessian Rhoen. 20 farm managers indicated that they would give up farming under these conditions. Only one of the farmers could imagine a continuation of farming, based on a positive stand on direct marketing, but would want to make a slow retreat from the profession.

Scenario C: 'a Clear Reduction in Financial Assistance'

Agricultural subsidies are reduced by 25% in all areas because of the expansion of the European Union. The subsidy structure for 2002 will, however, remain in force.

Four farmers would give up farming but would expect to find lease-holders for their farms. The number of farmers who would want to slowly abandon agriculture would increase to eleven. Eight of these would gradually lease off or sell their land, or not renew existing leasing agreements. Six farm managers assumed that their farms would continue to operate under scenario C conditions, although they did not give details about reasons and circumstances.

Scenario D: 'Payments for Ecological Performance'

The payments for agri-environmental measures increase by 20%. There is then a high reward for nature conservation and landscape stewardship work, due to a substantial strengthening of the 'second axis' of the agricultural policy (cf. Sect. 8.1).

From the point of view of the farm managers, this scenario would be the best option from the available choices. This can be seen from the fact that only two of the enterprises would give up farming. In both cases, the farm managers were at or close to retirement age and there was no successor. Five farm managers indicated that in the medium term, they would also want to give up farming under these conditions. However, four would not initially undertake any changes to their current use of the land and would not lease or sell any of it. Because of the improved payments for ecological services, 14 farmers assumed that their livelihood would be assured. Of these 14 farmers, 12 would extend their activities into landscape stewardship and extensification. Two farms wanted to continue along the lines of intensive organic agriculture. Only four of these farms would not expand their activities under the conditions of this scenario. The remaining ten would to a greater extent (over 50 ha) or lesser extent (1–5 ha) expand their farms.

Scenario E: 'Production of Premium Foods'

With an optimized regional marketing system, premium food products are produced. There is no financial support. The costs are covered alone through the raised price of the products.

With respect to this scenario, no clear assessment could be made by the farm managers. Within the framework of the investigation, however, current marketing activities could be ascertained, as could appraisals of future ways to carry out direct marketing:

- Only a few farms operated small-scale direct marketing. They do not consider direct marketing to be a viable prospect for the future.
- Professional contract marketing with outside help, as is already practiced on a small scale, is considered a viable future option by most of the farm managers.

With the currently low price level for beef in the production area, the marketing of quality meat is seen by the farmers only as a complement to income security in interplay with the existing financial support instruments, and in no way as an alternative to it.

7.6.4
Interpretation

The most important results of the survey are summarized below:

- The economic situation of the farms prevailing in 2002 was seen as more or less acceptable, or at least, not insupportable. Under a continuation of the situation (scenario A), however, half of the farm managers kept in mind that sooner or later, an abandonment of farming was a possibility, although they did not base this on financial aspects alone. As mentioned above, the uncertain situation regarding farm succession, the repeatedly expressed experience that the farm successor would not even want to carry on a financially viable enterprise was taken into account along with other factors.
- In scenario C, the pessimistic outlook rose as expected, although not dramatically or suddenly. With a reduction in financial support, fewer considered their livelihood as assured and more contemplated giving up farming. This is quite understandable.
- If the participants also did not give any clear answer with respect to scenario E which could have been recorded in Table 7.12, then they did not hide their skepticism about this model – quite realistically, as the results of Sect. 8.2 indicate.
- The almost complete agreement among farm managers with respect to the impossibility of operating an agricultural enterprise in the Rhoen without state financial support (scenario C) is easy to comprehend when one considers suckler cow farms. This assessment is fully confirmed in Sect. 8.1. The interpretation of the results from these suckler cow enterprises is less clear. It must be kept in mind that at the time of the survey, none of them enjoyed a particularly high level of support. They received the compensation payment and tolerated a poorly functioning quota system which was not effective at stabilizing milk prices and in some cases, they received farm investment support. Their negative answers may have indicated: 'Without financial support, it is impossible to produce milk' or 'My farm would not be able to produce milk without financial support because without it, I would not be able to achieve the necessary level of efficiency (output, animal numbers etc.)'. It is more likely that the answers should be understood in the light of the second version. Therefore, the scenario calculations in Sect. 8.2 come to another result.

- The unambiguously positive votes by the farm managers for compensation for ecological services are of great significance, in contrast to some of the statements from association functionaries. Clearly, the practising farmers have long recognized the multidimensional nature of their activities in the landscape and consider an income from landscape stewardship as no less due than one from product sales, despite the negative experiences of the former agri-environmental programs. The vote for scenario D is a demand on the agricultural policy to strengthen rather than weaken the 'second axis', as the years after the survey were to show.

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7.7
Oeland (Sweden) – a 'Historical' Pasture Landscape Supported by Environment Schemes and Modern Technology

Ejvind Rosén

7.7.1
Introduction

The island of Oeland in the Baltic Sea is the second largest island in Sweden with an area of 1 344 km^2 and a highest point of 57 m a.s.l. It is mainly built up by Cambrian and Ordovician strata. The latter forming the surficial flat limestone plateau which is gently sloping towards ESE. An escarpment (klint) is shaped along the western part of the island being part of a cuesta landscape (Königsson 1968).

During the latest glaciation period in Europe the area was covered by the land ice. This melted in the area about 12 000 years ago. A small narrow island developed by land uplift ca. 500 years later. The present shape of the island was obtained ca. 3 000 years ago (Forslund 2001).

Tills and some glacio-fluvial material were unevenly deposited on the bedrock and later stepwise reshaped and relocated as littoral material, now being old beach ridges in the landscape due to the land uplift. These ridges are very obvious in the so-called alvar areas. Vast areas are covered of sand, silt, clay and gravel. Scattered formations of eskers are present on the island (Königsson 1968).

In between gravelly deposits the bedrock is covered by thin weathered soils, which originate from the bedrock. These soils provide a basic soil reaction. Large areas – mainly alvars – have calcareous soils with a variation in depth from 1–20 cm and occasionally more.

The island is located in rain-shadow, of the Southern Swedish highlands, for the during summer prevailing winds from SW. For the central part of the island the yearly mean precipitation is ca. 440 mm. Usually there are periods with low precipitation during May–July, but this may fluctuate. With intervals of 7–10 years extreme summer drought periods occur (Rosén 1995). Windy conditions accenturate this drought for plants and animals.

The surrounding Baltic Sea creates a local maritime climate with a mild autumn and winter but late spring.

The mean temperature of the warmest month is +16.5 Centigrades (July) and the coldest −2 to −1 Centigrades (February) (more background information in Rosén 1982).

Many landscape elements are found on the island: such as alvars (limestone grasslands), fen areas, coastal grasslands, sand-steppes, a few small lakes and a very little share of wooded meadows. Woodlands (deciduous and coniferous) are mainly located to the central and northern parts of the island. Then there are scattered cultivation areas all over the island, but with the best soils in the south-western coastal part.

Alvar stands for a thin-soil calcareous grassland (Fig. 7.30). The main part of S. Oeland is occupied by Stora Alvaret (the Great Alvar) with a size of ca. 25 500 ha being the

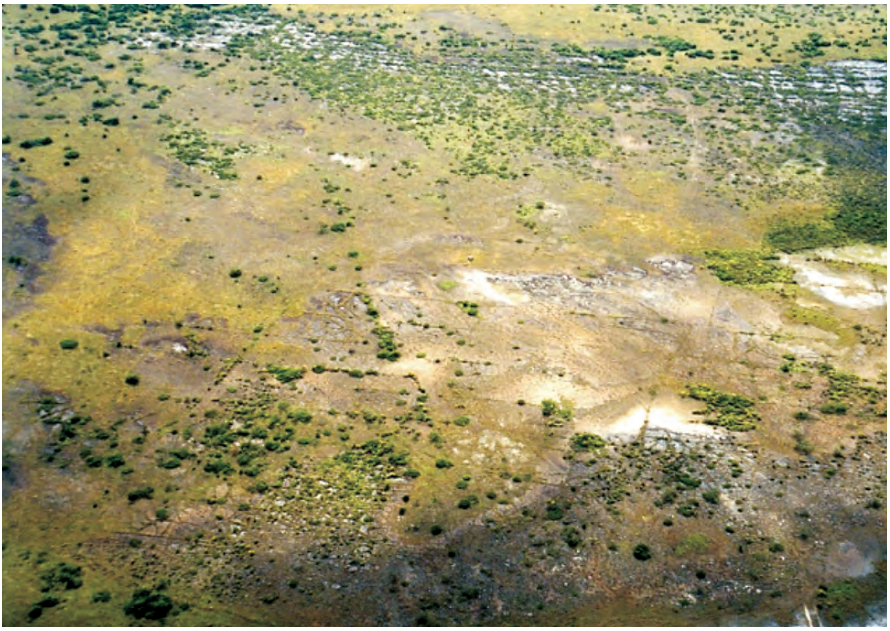

Fig. 7.30. Spatial structure of Stora Alvaret (the Great Alvar) (photo: C. Feucht)

largest alvar on the island and in the world. It represents 27% of the world distribution of alvars (Ekstam and Forshed 2002). In addition scattered smaller alvars are found up to the northern part of the island.

Alvars in Estonia show a high similarity with these on Oeland concerning, for example, core species (Helm et al. 2007), but also in structure (Pärtel et al. 1999; van der Maarel 2007).

The dominant habitat type in alvars is classified by the Natura 2000 as 'Nordic alvar and Precambrian calcareous flatrocks' – 6280. However with many transitions to other types (Eriksson and Rosén 2008).

The big variation of habitats on the island in general supports a high biodiversity of plants and animals. Concentrating our interest to the specific alvar-landscape with its mosaic of various habitats many interesting floral elements are found, such as: *Poa alpina* (Alpine/Montane); *Artemisia rupestris* (Continental/Siberian); *Ranunculus illyricus* (SE European); *Anthericum ramosum* (S. Europ.); *Globularia vulgaris* (SW Europ.); *Helianthemum oelandicum* ssp. *oelandicum*, *Artemisia oelandica* and *Galium oelandicum* (endemic to Oeland); (Widén 1980; Rosén and Borgegård 1999).

In the year 2000 the southern part of the island was declared by UNESCO as a World Heritage Area: 'The agricultural landscape of southern Oeland'. This includes all from cultivated areas to semi-natural grasslands, coastal meadows, archaeological areas, village structures and some woodlands. Emphasized was the long term continuous land-use by man.

7.7.2
Influence of Man in a Historical Perspective

The island was probably visited by man already 8000–6000 B.C. (resume in Alm Kübler 2001).

Archaeological findings verify that man was present about 6 000 years B.C. for hunting and fishing during summer conditions. Shortly after artifacts prove permanent settlements.

Four megalithic graves dated to ca. 3000 B.C. (all found in the vicinity of Resmo) tell about settlements during the Younger Neolitic (Farmers stone age) 4000–1800 B.C. These graves are located on top of the klint close to the Alvar in the western part where Oeland first arose from the sea – obviously with good living conditions for humans. Most probably people had their settlements in shelter just below the slope of the klint.

At that time cultivation and husbandry started in a small but regular scale. Pollen diagrams from sediments show an increased amount of pollen, for example, from *Plantago lanceolata* and a few other taxa – typical for grasslands (Berglund 1969). There is also evidence for the first "slash and burn" actions in the landscape (Ekstam and Forshed 2002).

From the Bronze Age (1800–500 B.C.) the second biggest grave mound (Mysinge hög) on Oeland is found in the same region. Thus indicating a continuous settlement and grazing influence in that area, but likely also in other regions of Oeland.

Around the end of Bronze Age a major climatic change to colder and moister conditions took place. This probably led to the development of permanent houses for humans and domestic animals.

During the Iron age (500 B.C.–A.D. 1050) there are evidence of human activities all over the island. An extreme expansion took place in the four first centuries C.E.

All soil that could be used was involved in agriculture practices (cultivation and grazing). Increased grazing supplied dung for the cultivation. An increasing population needed more land and also fairly barren places like alvars were used.

However, the high intensity of landuse led to overgrazing and erosion (Enckell et al. 1979).

In the Stora Alvaret area 48 house fundaments are known from that period (Königsson 1968) – most of which with water available for man and animals in the neighborhood. Several ancient stonewalls and farm structures are found in the landscape from this period (Fallgren 2006).

Within the period A.D. 400–550 there were unsafe and bad times in Europe with migrations and decrease for agriculture and trade – a fact which also influenced Oeland.

There were less grazing animals. Scrub-areas and woodlands were coming back again in deeper soil areas. Alvars started partly to be overgrown where deeper soils were present.

In the latter part of the Iron age a system with inlaying and out-laying land developed. The inlaying part included the houses, cultivated fields, hay-meadows and small paddocks for temporary stay of the domestic animals. All this land was surrounded by stonewalls or other fences.

Outside the wall was the out-laying land, a common land, which was used for grazing, timber production and temporary fields or meadows – within the "slash and burn" rotation system.

This organization of land created a base for the agriculture system several hundreds of years – until our modern agriculture system took over (see Fallgren 2006).

During the end of Iron Age and the first part of the Middle Ages (A.D. 1050–1523) trade and agriculture developed. Cattle, sheep, goats and horses were used and the grazing increased again in the landscape. This new expansion continued until the end of the 14th century, and then a new decrease took place. (Königsson 1968; Ekstam and Forshed 2002).

From the 16th and 17th centuries the land use increased again. In a book "History of the Nordic People" written in the mid 16th century by Olaus Magnus it is told about big herds of small and strong horses on Oeland. It is also reported an overabundance of cattle, horses, fish etc. which was sold abroad. In archives from Danzig it is verified, for example, that already 1474–1476 a number of 30 ship arrived from Oeland with oxen, horses, butter, cheese, lamb-furs etc. (Palm 1974).

The Ottenby area (southern part of Oeland, with pastures, hay-meadows and small woodlands) has been used for grazing and fishing at least from the Iron age. In 1546 a Royal estate was established in Ottenby and up today (with some exceptions) a large number of cattle and sheep are grazing these coastal grasslands (more info in Alm Kübler 2001; Ekstam et al. 1997).

In 1569 the Swedish King Johan III declared Oeland to be a Royal hunting-ground. Deers (*Dama dama*) and wild boars (*Sus scrofa*) were brought in. The declaration meant no cutting of trees in woodlands and no hunting of big game for people in general. Violation against the rules meant severe punishment.

People had to import wood for constructions and fire-wood from the mainland, but the poor had to collect what could be found in common land as alvars and coastal grasslands. All trees and shrubs were cut in these areas, creating a very open landscape, during this problematic period which lasted until 1801 – when the declaration was abolished.

Dung was collected from the pastures either for improvement of the poor fields or for burning in stoves. Importance of grazing animals increased (see observations in Linnaeus 1745).

Linnaeus further mentioned during his travel 1741 that the alvar area had an extension from Ottenby in south and up to Borgholm in north – not easy to understand today when seeing the so called 'Midland Forest' (Mittlandskogen). However, large areas in these present woodlands north of Stora Alvaret were more or less open pastures within common out-laying land.

Meadows sometimes hosted scattered shrubs and trees like *Corylus avellana*, *Tilia cordata*, *Ulmus glabra*, *Fraxinus excelsior* or fruit-trees like *Malus* and *Pyrus* (wooded-meadows). Shrubs and trees provided shadow allowing more grass vegetation to survive in their surrounding. Tree- and shrub-branches were cut and dried for animal winter fodder. After haymaking meadows were grazed for a limited period – part of the reason was to trample down the seeds into the soil assuring new plants to grow and produce hay next season.

After 1801 an exploitation period of several woodlands took place. New fields for agriculture were established.

The common (out-laying) land like alvars and coastal plains were split up and designated as common pasture land for the various villages.

A land regulation around the 1820s then subdivided the village common land and the cultivated land to private owners. This was followed by a large scale construction of stone-walls in the landscape.

Concerning the large alvar areas the stone-walls were constructed to separate the borders towards the neighbor villages. To construct walls for every narrow strip of private land was not possible. Thus the areas in principle continued to be used as a large common pasture for the villages (a situation mainly going on also today!).

For each village there was an internal council deciding how many animals each farmer was allowed to keep in the common pasture – but sometimes also how few! – to maintain a balanced grazing regime. This system partly exists also today in several areas – though with less animal- and landowners.

Poor times occurred during the latter half of 19th century due to increasing population and some extremely dry years with crop failure. Several people then decided to start a new life by emigration. Between 1880–1910 ca. 13 000 people (ca. 1/3 of the inhabitants) left Oeland mainly for North America (Palm 1974). Consequently grazing decreased.

7.7.3
Aspects of Landscape Change the Last Hundred Years

Though the number of inhabitants had decreased pine plantations (*Pinus sylvestris*) were established in several places (also in some alvars with deeper soils) to improve the availability of wood and wind-shelter.

Combined with the emigration and changed agriculture techniques the number of animals decreased during the first half of the 20th century. Statistics for Oeland show decreasing figures mainly for sheep, horses, oxen and bulls. Most drastic was the change for horses – being replaced by tractors.

In dry pastures like alvars *Juniperus communis* was expanding in a large scale (Rosén 1982). Other sources for heating, less horses and sheep enhanced the situation, though fire wood was collected up to the 1930s.

Less animals in agriculture and less collection of fire wood made it possible for shrubs and trees to regenerate and start up what has been classified as a scrub-encroachment and a nature conservation problem from the 1960s and onwards on Oeland.

However – during a limited period – in the 1950s and 1960s large scale sheep grazing was initiated in Stora Alvaret by governmental support for fencing. This was an attempt to bring back more grazing animals to these low productive grasslands.

There was even a try to use the lichen vegetation in some alvars for introduced reindeers (*Rangifer tarandus*), but the animals suffered by the dry and hot conditions and had to be remowed.

The grazing influence by sheep did not work out as good as expected. Too many animals and obviously a poor knowledge of the effects on vegetation productivity during summers with extremely dry conditions created too heavy grazing, lack of fodder etc. This finally resulted in bankruptcy for several of these sheep companies.

In 1963 there were 6 000 sheep in an area of 4 000 ha fenced land. There was an intention to manage 50 000 sheep in 50 000 ha, which fortunately was not realized (Martinsson 1965).

After the collapse for the sheep companies local farmers created a balanced sheep-grazing.

No doubt that some bush-areas in Stora Alvaret decreased during this intense sheep era during 10–15 years, but at the same time it was a clear negative impact on the structures of several plant-communities – resulting in loss of lichen- and moss-communities on bedrock areas or on thin soil; increasing weed growth around sheep barns and in heavy trampled and manure influenced places etc. (Sjögren 1971; Rosén and Sjögren 1971; Rosén 1982).

In the end of 1970s farmers stepwise by economic reasons abandoned alvar grasslands and preferred the coastal pastures which had higher and more reliable productivity and usually maintained a fresh vegetation during dry years. Governmental support for nature conservation reasons was given to coastal grazing – which at the same time favored the coastal birdlife.

Other farmers, mainly on the western side of southern Oeland decided to concentrate more on cultivation products.

Shrub-areas expanded with increasing speed (Rosén 1988a,b) and consequently grassland species decreased their abundance according to the increasing shrub canopy both in *Juniperus communis* and *Potentilla fruticosa* stands (Rejmanék and Rosén 1988). Only minor conservation practices were available. In 1994 less than 60% of the Stora Alvaret area was grazed by domestic animals. A desire to maintain an open landscape seemed to be hopeless.

7.7.4
LIFE-Project and European Environment Schemes: a Turning Point

In 1996 it became possible for the Kalmar County Administration to start the project: ‘Protection and restoration of parts of Stora Alvaret’ with financial support from the European Union (Life Fund) and the Swedish Government via the Swedish Environmental Protection Agency. About €1.5 Million was available for a 4-year project.

The aims in brief were:

- Clearing of 1500 ha overgrown shrubland (*Juniperus communis* and *Potentilla fruticosa*);
- Rebuilding of stone walls and fences;
- Enabling the local farmers to graze the areas on the basis of temporary grazing contracts;
- Increasing the general awareness of Stora Alvaret’s natural and historical significance.

An overall objective of the project was that 90% of the project areas should become well established grazing lands by the year 2000 hosting habitats and species that are characteristic of the area (Rundlöf Forslund and Lager 2000).

After the LIFE project period the large scale support with the European Union agri-environment schemes were realized and grazing intensity continued to expand for the whole island and so did clearings, renewal of fences etc. Indeed a very positive trend has started. Never before, and in such a short time, so large scale conservation managements have taken place in Oeland.

A parallel project to the general environmental support was a new LIFE project (2000–2005) concerning wetlands and moist meadows in various parts of the island. Some of these areas are found in the Stora Alvaret area as well.

7.7.5
Methods for Restoration

From the beginning of the project a fruitful discussions and cooperation between landowners, administrators and scientists begun. Many questions about selection and size of areas, methods for clearing, tools, transports etc. were dealt with.

Part of these questions could be tackled by experience received from several small scale projects in alvar vegetation since the end of the 1960s concerning expansion of shrub-lands, effects on biodiversity, seed-bank in the soil etc. (Rosén 1982, 1988a,b; Bakker et al. 1996).

A general rule for clearings was to select places where productive alvar areas could be brought back again into a grazing-regime.

It was judged to concentrate clearing actions on small and intermediate sizes of junipers as long term monitoring research had shown these grow faster than the older ones (Rosén 1982, 1988b). Stands or groups of older shrubs were left, glades were widened and corridors were created between dense parts of the scrub to favor dispersal of seeds from open grassland species into opened areas.

Potentilla (Dasiphora) fruticosa had to be limited as it tended to invade and become dominant in moist and wet grasslands (Fig. 7.31). Several trees in open grasslands were cut unless they were important as shelter for animals or of value for breeding birds.

Near alvar lakes and temporary pools trees were removed if they served as observation points for predating birds when hunting i.e. waders. This extra effort because waders were rare in the area.

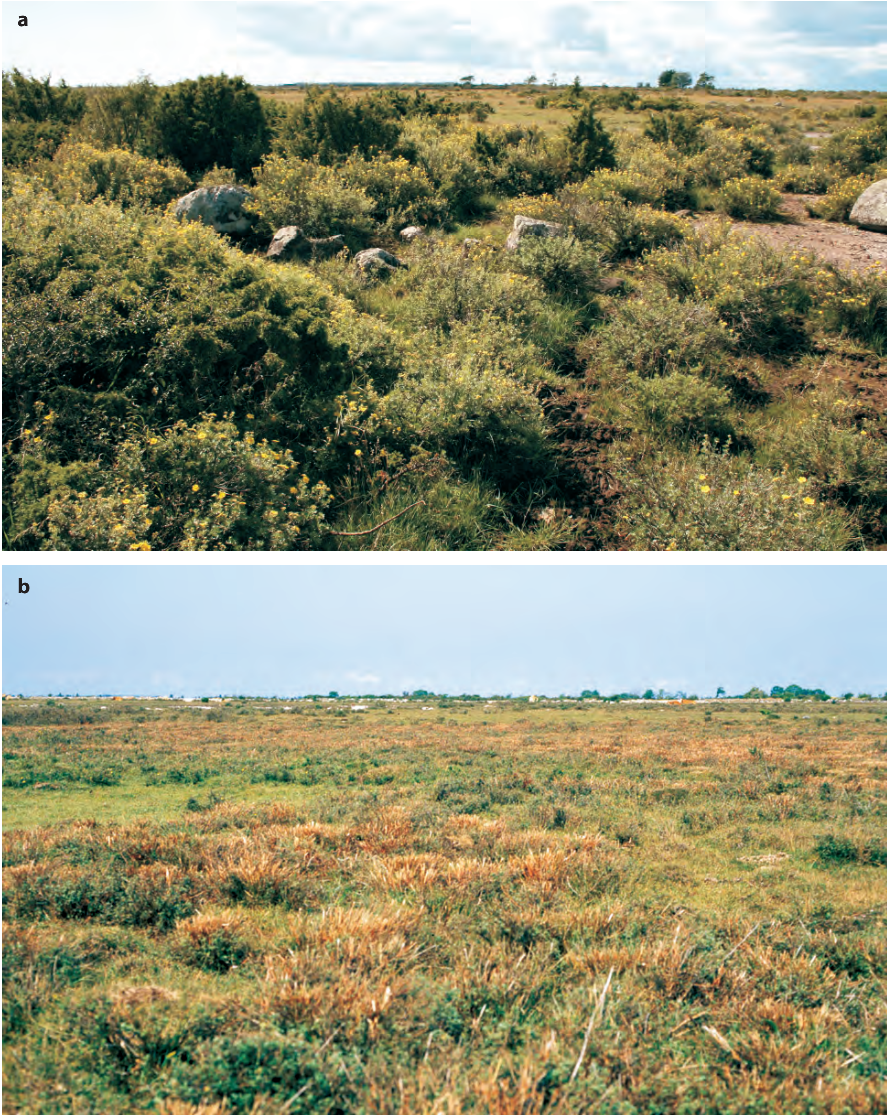

Fig. 7.31. a Expanding *Potentilla fruticosa* stand (photo: E. Rosén) and **b** removal by management measures (photo: H. Plachter)

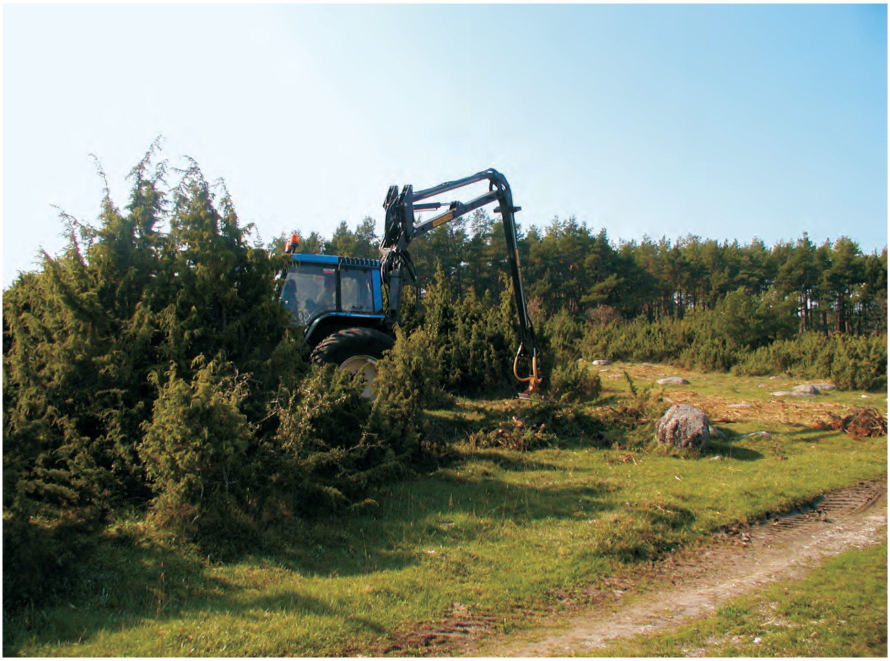

Fig. 7.32. Selective clearings by tractor equipment in a dense Juniper scrub (photo: E. Rosén)

For restoration of these large areas of Stora Alvaret it became obvious that normal motor-saws and chippers were not enough. Especially concerning *Juniperus communis* and *Pinus sylvestris* larger tools and machines were needed. Small private enterprises developed and tools were constructed for clearings in various habitats. Tractors with wide wheels and mobile arms with saw equipment developed (Rosén and Bakker 2005) (Fig. 7.32).

The local government in Kalmar provided detailed maps with information about areas which had to be thinned or cut. At the same time a detailed digital vegetation map was produced for the southern part of the island – and later on for the northern part. With GPS actual areas were found in the field.

Cutting of junipers was done at the soil surface level. Very small shrubs were usually smashed into pieces by a rotating chain equipment. Shrubs were burned in mobile containers or on the ground in places where no damage would occur. An attempt to bring cut shrubs to central heating stations was not fulfilled as the transports needed more energy (fuel) than could come out of the cut shrubs. Besides transports created undesired tracks in the thin soils.

When the soils were very wet it was not allowed to drive with vehicles in such areas (More information in Rosén and van der Maarel 2000; Rosén 2006).

The animals had to produce a well grazed vegetation canopy on average over a few years. Administrators from the local government in Kalmar controlled that the aims for a certain area were fulfilled.

Within the schemes of agri-environment support following main types of pastures in Oeland have been involved:

- Alvars – large areas with various structures of soils and dry to moist conditions, mainly calcareous.
- Semi-natural grasslands – mainly coastal grasslands, moist to wet areas on littoral material, sand-heaths – partly calcareous.
- Woodland pastures – combination of open woodland and open areas mainly on fertile soil.
- Traditional hay meadows – wet to dry, not fertilized, only grazed a short time per year.

7.7.6
Analysis of Recent Changes in Domestic Animal Numbers

Cattle

In Sweden cattle total number has decreased ca. 36% within ca. 50 years (1951–2007) (Table 7.13). The most drastic figures are shown for the dairy cattle (milk producing cows), with a decrease of 76%. Figures for calves and cows producing calves are fluctuating.

Table 7.13. Number of cattle in Sweden, Kalmar County and Öland during 1951–2007. In 1951 the category heifers etc. include figures for cows producing calves (Kalmar County)

Year	1951	1981	1990	1995	2003	2007
Sweden						
Dairy cattle	1 564 905	660 795	576 409	482 118	402 520	369 646
Cows producing calves	317 180	70 582	74 544	157 128	164 718	185 717
Heifers, bulls, steers	480 592	610 917	543 458	595 521	527 204	515 737
Calves less than 1 yr	88 978	596 514	524 032	542 328	512 232	488 625
Cattle total	2 451 655	1 938 808	1 718 433	1 777 095	1 606 674	1 559 725
Kalmar County						
Dairy cattle	77 847	49 880	46 973	42 903	40 651	39 770
Cows producing calves	no data	3 947	4 792	9 196	11 254	12 347
Heifers, bulls, steers	28 906	46 268	44 087	47 316	48 064	49 314
Calves less than 1 yr	22 849	43 185	41 645	42 619	45 034	43 972
Cattle total	129 602	143 185	137 497	142 034	145 003	145 403
Oeland						
Dairy cattle	13 370	14 579	14 872	14 658	14 981	15 762
Cows producing calves	no data	673	991	1 979	2 834	3 236
Heifers, bulls, steers	5 772	12 998	13 479	15 568	17 867	19 528
Calves less than 1 yr	5 257	12 963	13 557	14 129	16 475	17 041
Cattle total	24 399	41 213	42 899	46 334	52 157	55 567

For Kalmar County there is a decrease of 49% for dairy cattle. This is compensated for by small increases for the other categories – especially by cows producing calves. Changes have been fairly small the last 20 years. In total there is an increase for cattle (12%) the last 50 years.

On Oeland the number of cattle have been more than doubled over the 50 years – with increased figures for all categories. During the period since 1981 the increases are (dairy cattle) 3%, (cows prod. calves) 321%, (heifers etc.) 37%, (calves) 27% and cattle in total 27%.

Sheep

For number of sheep figures are fluctuating over the last 50 years, but totally there is an increase for Sweden, Kalmar County and Oeland (Table 7.14).

An additional expose of sheep grazing in a longer perspective gave some interesting figures: In 2003 there were 12 537 sheep on Oeland which could be compared with the years 1571 and 1641 with figures: 12 721 and 13 793 sheep respectively. The highest figure is recorded from year 1865 with 18 094 sheep.

Then the numbers were oscillating between 12 000–16 000 sheep (1910–1927).

After that a decrease started (1944): 8 972; (1951): 3 914; (1956): 2 723. However in the end of the 1950s the large scale sheep grazing started in the southern part of the island and figures for Oeland increased (1961): 4 063; (1966): 10 500; (1971): 10 306; (1976): 16 010; (1981): 14 739. For the period 1990–2007 the numbers were stabilized on a lower level (as shown in Table 7.15).

Horses

Concerning horses there is an increase around 100% all over the country the last 20 years (Table 7.15). The numbers are in reality much bigger as the figures only tell about horses connected to farm enterprises. Sport horses etc. are not included! A prognosis for all horses on Oeland today is ca. 2000.

Table 7.14. Number of sheep in Sweden, Kalmar County and Oeland during 1951–2007

Year	1951	1981	1990	1995	2003	2007
Sweden	207 668	403 211	404 799	461 849	448 308	508 921
Kalmar County	13 557	42 739	34 509	27 905	33 649	35 124
Oeland	3 914	14 739	10 981	11 081	12 537	11 631

Table 7.15. Number of horses in agriculture in Sweden, Kalmar County and Oeland during 1981–2003. No comparable data for 1951 and 2007

Year	1981	1991	1995	2000	2003
Sweden	50 662	76 805	84 548	88 621	95 499
Kalmar County	2 037	2 652	3 329	4 099	4 654
Oeland	430	597	785	731	844

In a wider perspective available statistics from Kalmar County give figures around 31 000 horses in 1913–1914. It had increased to ca. 35 000–36 000 (1919–1946) and with a maximum 37 721 (1940).

Then a stepwise big decrease: 25 812 (1950); 11 110 (1960); 2 737 (1970) followed by a slow decrease (Table 7.15). Probably there were about 8 000 horses on Oeland (1920s–1940s).

(Statistic information provided from: The Swedish Board of Agriculture, Statistics Sweden and Kalmar County Administration.)

7.7.7
Conclusions

Abandonment of grazing and scrub-encroachment resulted in loss of considerable areas of good pasture land, and changed conditions for species involved. Rejmánek and Rosén (1988) showed a continuous decrease in number of grassland species due to increased canopy cover of the shrub *Potentilla fruticosa* and a drastic dip at 75–80% of *Juniperus communis* cover (see Fig. 7.34). Inside a juniper bush ca. 80 years without grazing, Bakker et al. (1996) found ca. 55% loss of grassland species, and 80% had vanished in the soil seed bank. Variation in number of and type of grassland species also correlate to the juniper size and shape (Rosén and Sjögren 1988).

Scrub clearings allow light demanding species to come back from the seed bank, but also from outside (Zobel et al. 1996). Bakker et al. (1996) claimed that new seeds have to be dispersed from outside by wind or grazing animals. On Oeland cleared corridors from open areas into recently opened glades inside a scrub supported this.

Re-vegetation on patches (or larger areas) where junipers had been removed needed approx. 5 years for re-colonization, which fits well with permanent plot recordings from the 1970s showing 5–7 years (Rosén 1982).

Rusch (1993) found that gap formations of various size and at different times of the year supported seedling establishment in the field vegetation. Variation in seedling density was associated with early fluctuations (cf. turn-over experiments by shading, fertilization and watering by Huber and van der Maarel 2007).

The reintroduction of grazing supported these needs of small and intermediate gaps in the plant canopy via trampling – not least by tracks from sheep. More large-scale gaps and open soil patches, which were created by various tools and vehicles, supported a bigger share of re-vegetation.

Cirsium spp. was found as a characteristic and successful pioneer the first couple of years in several areas. As being wind dispersed plants their seeds had for several years been caught in the scrub, been waiting in the seed bank – and then suddenly initiated to grow by good light conditions and free soil after the clearings.

Monitoring of permanent vegetation plots in an alvar area being re-introduced to cattle grazing in 1996 showed a clear change in structure of the vegetation canopy over time (5 yr) The vegetation became shorter and contained less dead plant material. Most species gotten a more even distribution in the plots. In some permanent plots the number of species increased with a few specimens over time, enhancing the biodiversity (Rosén and Bakker 2004).

A similar development is confirmed by Helm et al. (2007). After 10 years this trend is still valid. Extreme drought periods some years are adding a fluctuation aspect.

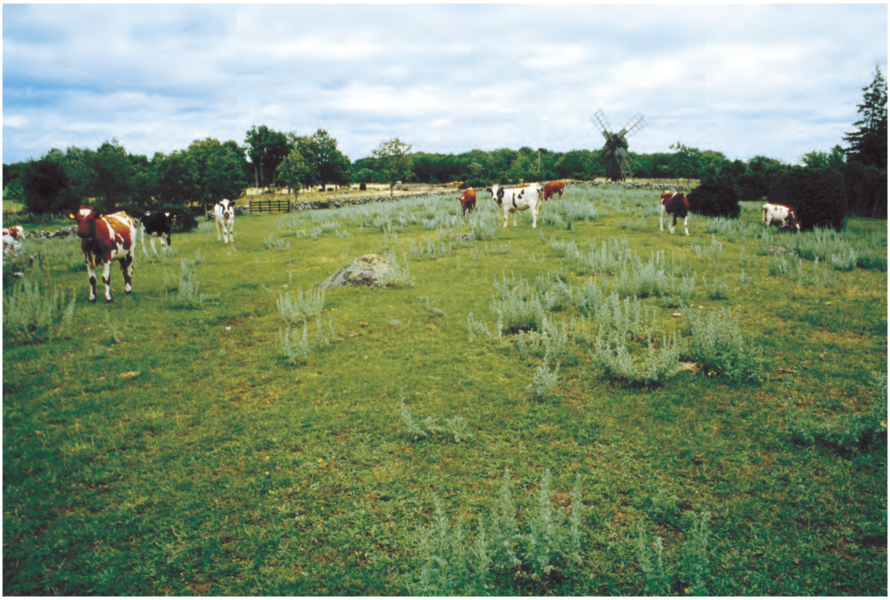

Fig. 7.33. Invasion of *Artemisia absinthum* into a cattle pasture, induced by overgrazing (photo: E. Rosén)

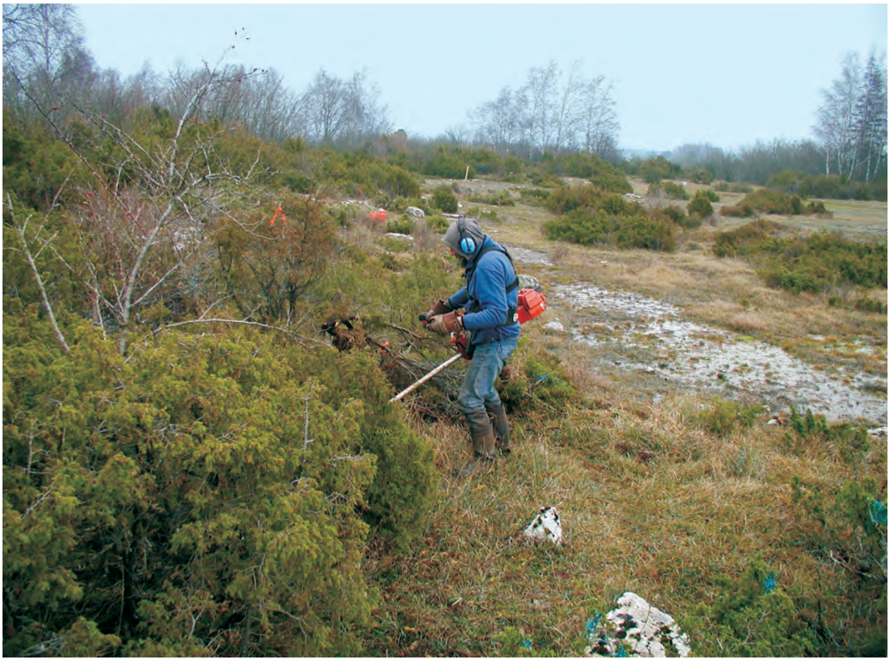

Fig. 7.34. Fighting against Juniper (photo: E. Rosén)

Species are coming and going due to the so-called 'Carousel model' (van der Maarel and Sykes 1993).

Information from Kalmar County Administration about clearings of scrub areas in Stora Alvaret tell that – during two Life-projects after each other (1996–2005) and then within the European agri-environment schemes (2000–2006) – in total 5.053 ha alvar pastures have been treated. Some voluntary initiatives may increase that figure. In addition to that large areas in central and northern parts of Oeland have been cleared as well.

As mentioned above the number of grazing animals has increased considerable. All over the island a living pasture landscape is coming back. For the Stora Alvaret area today ca. 99% is being grazed – thus an increase with at least 40% in ca. 10 years period. Without the EU support this would never have taken place.

Experience from field work and monitoring in several areas indicate a negative response to the increased grazing influence. Species like *Anthericum ramosum*, *A. liliago*, *Artemisia oelandica*, *Senecio jacobaea* ssp. *gotlandicus*, *Ranunculus illyricus* and some more are frequently being grazed (Rosén and Bakker 2005). This has resulted in reduced population size, lack of seed production etc.

Already a problem for the future has appeared with the appearance of invasive species like *Artemisia absinthum* and *Daucus carota*. They expand in trampled vegetation near gates, but also in some cleared shrub areas – and these plants are not tasteful for animals to eat (Fig. 7.33)!

As a result of inventories and classifications most alvar areas are designated as Natura 2000 sites and so are most of the coastal grasslands.

Several species found on Oeland are now listed in the European network for valuable species. Examples from pastures: *Artemisia oelandica* (endemic to Oeland); *Senecio jacobaea* ssp. *gotlandicus* (endemic to Oeland and Gotland); *Sisymbrium supinum*; *Tortella rigens* (endemic to Sweden and Estonia), (see Cederberg and Löfroth 2000).

From the more practical side a lot of experience was gained during the projects. To manage large scale clearings various kinds of machines were needed. For rock areas and thin soils the damage tended to be too high by vehicles. Instead hand carried equipment was the solution.

Grazing after clearings, in areas with deciduous shrubs like *Potentilla fruticosa*, has to start before young shoots became lignified – otherwise animals avoid to browse them. Browsing patterns and relations between grazing and water-access are shown in articles by Feucht and Rodenbeck (in this book).

These restorations – to a high extent taking place in Stora Alvaret – have been a positive influence for the economy of farmers, the co-operation between people involved – and no doubt for the continuation of the traditional pasture landscape on Oeland.

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Chapter 8

Implementation of Large-Scale Grazing

8.1
The Economics of Large-Scale Livestock Grazing in the German Low Mountain Ranges with the Example of the Rhoen

Michael Rühs · Ulrich Hampicke

8.1.1
Introduction

This chapter summarizes the level of understanding about large-scale livestock grazing under the conditions existing in the low mountain ranges of Germany. Following the description of the investigation area in Sect. 8.1.2, Sect. 8.1.3 will introduce a financial calculation of cattle keeping which, although specifically based on the Rhoen area, can also offer orientation with the necessary modifications. Sect. 8.1.4 contains a brief view of the economics of sheep farming, followed by Sect. 8.1.5 with a comparison with figures from the literature. Sect. 8.1.6 summarizes the grazing alternatives which are currently available, including unconventional procedures. In Sect. 8.1.7, there is an overview of possible changes to the economic framework conditions in the future as well as the effects of future agricultural and agri-environmental policies before finally, recommendations are presented in Sect. 8.1.8. The calculations presented here confirm descriptions from literature for the years 1990 to 2000 concerning the precarious economics of the production of cattle and sheep meat (e.g., Anonymus 2000; Deblitz and Balliet 1991; Deblitz 1993; Fechner and Priebe 1998; Göbbel 1994; Hochberg and Neubert 1999; Karwath and Weiher 1993; Schalitz and Fechner 1998; Seliger 1994; Weiss 1986). It is the financial support alone which makes this production branch viable. However, particularly in nature conservation literature, insufficient attention is given to the consideration that other grassland uses such as heifer breeding for dairy production are more viable from an economic viewpoint (c.f. Anonymus 2003; Heinze 1991; Lührmann 2001, 2004). More details will be given about this later.

8.1.2
The Investigation Area

The center of the economic investigations is the Rhoen, with sections in Hesse and Thuringia. In addition, there are surveys from other areas included, which are of particular significance, especially for the outlines of sustainable methods of cattle farming. Information on sheep farming in the Swabian Mountains is also used.

The discussion on the various scenarios (see Sect. 8.2) is concentrated on the municipality of Ehrenberg in the Hessian Rhoen, situated in the Ulstertal close to the borders with Bavaria and Thuringia. It is part of the agricultural economic area of the East Hessian low mountain ranges (for economic areas, see Haen 1979). As well as the Rhoen and large parts of the district of Fulda, this area comprises the whole district of Hersfeld-Rotenburg and parts of the Werra-Meißner and Vogelsberg administrative districts. Overall, this largest of the economic areas in Hesse is considered as a relatively unfavorable agricultural region (average yearly temperature 6.5–8 °C, yearly precipitation 550–700 mm, farmland grading index 37).

From a selection of representative municipalities in the Rhoen area, Schramek et al. (1999) report an average yearly precipitation of 742 mm and a farmland grading index of 35 at a height above sea level of 430 m. With respect to the agricultural production conditions, the investigation area is therefore disadvantaged in a region already classed as having a poor economic base. The effects of these unfavorable conditions for agriculture and the limited complementary or alternative employment opportunities have been a trend towards outward migration, particularly of younger people towards the nearby urban centers in the south of Hesse (Schramek et al. 1999).

Overall in Hesse, there is a trend towards farm sizes of over 50 ha with a simultaneously shrinking livestock density. According to information from the Hesse Agricultural Report (HMULF 2003), only farms of a size over 75 ha can be counted among the growing enterprises (Table 8.1); for 2007 the HSL (2008) states a growth threshold for farms at above 100 ha. The growth farms are in competition with each other for the land given up by their fellow professionals who are leaving the industry. With respect to the structural developments in agriculture in the economic area of the East Hessian low mountain ranges, Schramek et al. (1999) have ascertained a general tendency towards expansion of existing farms while there is a yearly abandonment of about four percent of all farms.

Table 8.1. Development of farm enterprises in Hesse according to size (HDLGN 2002)

	1995	1999	2001	Changes 1995 to 2001 (%)
1–10 ha	20022	12739	1250	−43.8
10–20 ha	6960	5625	5460	−21.6
20–50 ha	8011	6740	5976	−25.4
50–75 ha	2272	2263	2225	−2.1
75–100 ha	954	1128	1178	+23.5
>100 ha	838	1174	1340	+59.9
Total	30057	29669	27429	−29.8
Ø Area size (ha/farm)	19.9	25.8	27.9	+40.7
Farm area in ha total	775597	765979	766310	−1.2
Growth threshold (ha/farm)	50	75	75	

Growth threshold national average 2001 at 75 ha.

Assessments by Schramek et al. 1999 and results of the work presented here (see Sect. 7.6) indicate a comparably low level of land under use by farms in municipalities of the Rhoen, averaging about 35 ha. In addition, the small-scale pattern of ownership resulting from permanent division of patrimonies over generations has made farming more difficult for the remaining enterprises. Between favored regions and the peripheral areas, there are counter developments with respect to the arable-grassland relationship, and in the last few years in the East Hessian economic region, the already high proportion of grassland has grown further at the cost of arable land. The farms with large grassland areas in this region use the agri-environmental programs available for grassland extensification and for the participation in ecological farming with equal take-up while in favorable regions, these programs have made little impact. The main production emphasis for farms tied into agri-environmental programs is on suckler cows. If one compares the assessments of Schramek et al. (1999) of a selection of municipalities in the East Hessian low mountain ranges with the structural data for three municipalities in the Hessian Rhoen, (cf. Table 8.2), it turns out that the tendency to grassland farming is more characteristic in the Rhoen area than in the East Hessian economic region. Therefore, the conditions in the investigation area can be seen as not only typical for the region but even as having reached a worrying level.

Table 8.2. Agricultural land and main use types: a comparison of different municipalities in the East Hessian low mountain ranges (LMR) and the Hessian Rhoen

	Area (ha)	Arable (AL) (ha)	Grassland (GL) (ha)	AL (%)	GL (%)
Hessian Rhoen					
Ehrenberg	1 846	162	1 683	9	91
Gersfeld	2 457	288	2 168	12	88
Hilders	3 115	616	2 498	20	80
East Hessian low mountain ranges					
Tann	3 484	872	2 607	25	75
Rasdorf	1 865	876	988	47	53
Nusttal	2 214	935	1 276	42	58
Hofbieber	4 280	1 792	2 486	42	58
Dipperz	1 858	851	1 007	46	54
Künzell	1 865	956	901	51	48
Poppenhausen	2 635	617	2 018	23	77
Ebersburg	2 341	991	1 349	42	58
Total East Hessian LMR	20 542	7 890	12 632	38	62
Total Hessian Rhoen	7 418	1 066	6 349	14	86

Source: Hesse Agricultural Report (HMULF 1995) and Municipality results (HSL 1997).

8.1.3
Model Calculations for Cattle Farming

General

In the following section, model calculations for different variants of grassland use with cattle farming are presented and discussed with regard to the significant results. The calculations refer to the project area in the Rhoen and are therefore based on conditions of low mountain ranges but can be extended to other areas with some modification. The results are the basis for appraisals in the scenarios for future uses under changing conditions of financial support from the Common Agricultural Policy of the EC in Sect. 8.2.

In this section, only established agricultural enterprises which have the objective of producing market products are examined. From the standpoint of nature conservation, activities are also of interest in which landscape stewardship activities such as grazing takes place but which do not produce marketable goods. More about this follows in Sect. 8.1.6.

In the calculations, the viability of the particular branch is tested through full cost accounting, in which all calculable costs of a production procedure are included. The accountability is a known and often insoluble problem in mixed enterprises, for which marginal costing is more suitable. In the model calculation presented here, sufficient accountability can be assumed. Table 8.3 gives a description of the calculation.

There are variable (or proportional) and fixed costs to be regarded. Variable costs fluctuate with the scale of the production (two cows eat more than one cow) and arise only when there is actual production. An area of fallow land or an empty stable does not give rise to variable costs. Important variable costs in livestock farming include costs for increasing stock numbers, green forages, veterinary costs etc.

Fixed costs are independent of the extent of the production within the framework of the existing capacity and arise even when production stops. A stable causes fixed costs whether it is empty or full of animals. In the farm enterprise, the costs arising from the labor of the farm manager's family are also fixed for the calculation, as an income must be generated (seasonal workers on the other hand are variable costs). In the calculation presented here, a target income in the form of an hourly rate is as-

Table 8.3. Model for a full cost calculation in an agricultural enterprise

		€ per animal or per ha per year
1	Variable costs	
2	Fixed costs	
3	Full costs (1 + 2)	
4	Earnings from market sales	
5	Contribution margin (4 – 1)	
6	Profit/loss (4 – 3)	
7	Subsidies	
8	Profit/loss after subsidies (6 + 7)	

sumed. In practice, however, the family income appears as a residual earning after deduction of all costs.

An important concept here is contribution margin (CM) that is the difference between market earnings and variable costs. It serves to cover the fixed costs and the profit/loss and is the basis for the optimal selection of production branches with unchangeable fixed costs. In livestock farming, there is normally a differentiation between CM I and CM II (without and with deduction of costs of basic green forages). For the purposes of this exercise, it is important that profit/loss, as in Table 8.3, is defined as the difference between market earnings and full costs (line 6), as only in this way the viability of a production branch can be determined from market data and the competitiveness of different production branches can be compared. For the farm manager on the other hand, drawing his income from the sum of market achievement and support payments, the result in line 8, Table 8.3, is more important, showing the performance including support payments. For economic and agricultural/nature conservational purposes, an orientation of this order only leads to confusion as because of the support payments, the production branch in question appears more successful than it actually is in the market.

The detailed Tables 8.5–8.8 are oriented to the model in Table 8.3 but show separately costs for basic green forages (belonging to variable costs) and labor costs (included with fixed costs). A labor remuneration of €12.50 per hour is assumed. For the fixed costs, only those for stable provision and fencing are included. This is because the production of green forage is considered an independent production branch within the farm and is loaded onto the fodder costs. Table 8.4 shows four different green forage production processes with full costs of €0.02 up to €0.13 per 10 MJ ME. The energetic evaluation of fodder is laid down for cattle and sheep meat production in the unit ME (metabolizable energy). In this production branch, it is usual to calculate in quantities of 10 MJ (megajoules = 10^6 Joules). This procedure will be drawn on in Table 8.5–8.7.

The fixed costs are given in Table 8.5–8.9 with the annuity formula:

$$A = \frac{Ki(1+i)^T}{(1+i)^T - 1}$$

where K is building costs, i is interest rate and T is the life duration. The interest rate for the calculation remains constant at 6% per year; to this are added yearly upkeep costs amounting to 1.5% of the building costs. The cost situation mainly reflects the data from KTBL (2002) for the assumed size of the farm; earnings are taken from market data from 2003 (HDLGN 2003). It is clear that all figures can deviate strongly in some cases because of individual circumstances and efforts, marketing opportunities, etc. but this in no way diminishes the value of the data presented here as a model calculation. As in the case of leasing payments, non-specific general overhead costs applying to the farm (farm management, insurance, contributions etc.), are deliberately left out of the tables. Both factors make the operation more expensive for the particular farm, which without doubt is taken into account in the costing of the enterprise. However, the following is concerned with a comparison of the different *procedural costs*. The comparison is subject to overheads and leasing payments being always equal, independent of the selection of a procedure.

Table 8.4. Full costs of green forage production with four different procedures (source: authors' calculations with data from KTBL 2002; *wh:* working hour)

a Winter fodder (mowing)	**Quantity**	**Costs (€/ha)**		
		1st mowing	**2nd/3rd mowing**	**Sum**
Permanent grassland; 20 ha; ecological farming 1st mowing: silage (Forage Harvester); 2nd and 3rd mowing: hay (Round Bale Press)				
Variable costs				
Machine costs		74.32	86.81	247.94
Gasoline (l)	107.4	11.31	9.92	31.15
Labour costs (wh)	15.03	69.13	59.38	187.88
Fixed costs (annuity, insurance) for machines				271.34
Total costs				738.30
Costs: € per 10 MJ ME (at 57 000 MJ ME net harvest)				0.13
Permanent grassland; 20 ha, conventional agriculture; silage (Forage Harvester); all 3 mowings				
Variable costs				
Machine costs		80.65	41.39	163.43
Gasoline (l)	83.1	12.21	5.95	24.10
Mineral fertilizer (t)	1.8	150.00	60.00	270.00
Labour costs (wh)	10.19	60.88	33.25	127.38
Fixed costs (annuity, insurance) for machines				178.29
Total costs				763.19
Costs: € per 10 MJ ME (at 70 000 MJ ME net harvest)				0.11
b Summer fodder (pasturing)	**Quantity**	**Costs (€/ha)**		
Dairy cows; rotational grazing all day pasture; 2 times daily stable milking; net harvest: 60% of total harvest (70 000 MJ ME) = 42 000 MJ ME				
Variable costs				
Machine costs		30.00		
Seedings (every 6 years)	20	6.33		
Mineral fertilizer (t)	0.5	75.00		
Labour costs (wh)				
for animal care	2.75	34.38		
for maintenance	5.7	71.25		
Fixed costs (annuity, insurance)				
for machines		18.00		
for pasture equipment		34.00		
Total costs		268.96		
Costs: € per 10 MJ ME (at 42 000 MJ ME net harvest)		0.06		
Young cattle; permanent pasture without maintenance and fertilizing; all day pasture; net harvest: 75% of total harvest (40 000 MJ ME) = 30 000 MJ ME				
Variable costs				
Machines		7.30		
Labour costs (wh) for animal care	2	25.00		
Fixed costs (annuity, insurance)				
for machines		4.50		
for pasture equipment		25.00		
Total costs		61.80		
Costs: € per 10 MJ ME at 30 000 MJ ME net harvest)		0.02		

The relationship between earnings and costs is not an unchangeable feature of a production branch. Much more, it is dependent on the particular efficiency of a farm. In general, efficiency increases with the size of the farm, whereby over a particular threshold, there are no unit cost advantages to be achieved. In general in the Rhoen area, this threshold is a long way from being achieved. The farm conditions described briefly above lead to high efficiency losses. For small enterprises, understandably, the labor and stable costs per animal are significantly higher than for larger ones. Without doubt, these structures will change in the medium to long term future, so that – apart from hobby farmers – in the future of the Rhoen area also, there will either be an efficient use of land or no use at all.

Because of the future orientation of the observations made here, it makes no sense to carry out costing for the current small-scale farm structures. Full cost calculations for these would produce even worse results than the following calculations. They would also be notional because most of the enterprises abandoning farming over the longer term do not need to consider full costs. If a stable is written off and is not in need of replacing, then there are no fixed costs arising.

For this reason, for the calculations, model farms were assumed which exceed in terms of size and efficiency the majority of present-day farms but take into account however, the nature conservation conditions as well as the historical situation of the enterprise. In part, parallel calculations were carried out for clarification purposes, for example, with stocking levels of 40 or 120 dairy cows whereby the latter level is the more sustainable from an economic viewpoint.

Consideration is given to the systems of suckler cow keeping, bullock fattening and heifer breeding for suckler cows as well as dairy farming. It is clear that the latter is not included with production branches interesting from the point of view of nature conservation as the cows require energy rich feed, that is, made from frequent and early cutting and generally low in species numbers. As it will be seen later, however, their indirect significance is in their connection with heifer breeding.

Suckler Cow Farming

With regard to the organization and the product range, suckler cow enterprises are very variable. As well as the production of baby beef or calves, the fattening of young animals and their use in milk production or for sale as breeding animals are available options. The common factor for all procedures is that the milk produced is used only for feeding the calves and the calves remain on the pasture with the cows until they reach a specific age. As a 'central procedure' in the model, the keeping of 100 cows with calf production has been selected. The young animals are kept in the herd until they reach a mass of 250–350 kg for selling. In a well-organized system, calving takes place in spring time shortly before pasturing season. All details can be read in the box at page 357. Two procedures are compared – with conventional winter stable keeping and winter outdoor keeping. Opinions are divided over the latter as a suitable procedure in the mountain areas (Müller and Wagner 1997a,b; Opitz v. Boberfeld 1997; Warzecha et al. 1998); there are some benefits to be gained.

The values in Table 8.5 are given per hectare and year. Because for both procedures the stocking densities are about one suckler cow per hectare fodder acreage (summer

Table 8.5. Full cost calculations for two procedures of suckler cow keeping in comparison

Suckler cow – feeder cattle production **Number of suckler cows per ha**				**Winter stable 0.99**	**No stable 0.92**
Expense factor	**Unit**	**Quantity w./no stable**	**Price per unit**	**Result (€/ha)**	
Variable costs			€		
Restocking	Heifer	0.17	827.15	139.18	129.34
Feed concentrate	dt	2.2	12.50	27.23	25.30
Mineral feed	dt	0.5	45.00	22.28	20.70
Stud fee			20.00	19.80	18.40
Vet/medicines			20/25	19.80	23.00
Insurance			10.00	9.90	9.20
Energy/water/fuel			30/18	29.70	16.56
Bedding	at	6/11	3.50	20.79	35.42
Others			10.00	9.90	9.20
Interest on working capital	%	6		12.87	12.88
Interim sum variable costs				*311.44*	*300.00*
Costs fodder production		w./no stable	€/10 MJ		
Winter fodder (meadow)	MJ ME	22 400/26 880	0.13	288.29	321.48
Summer fodder (pasture)	MJ ME	24 800/24 800	0.02	49.10	45.63
Interim sum fodder production				*337.39*	*367.12*
Labour costs		w./no stable	€		
Summer period	wh	6.5/6.5	12.50	80.44	74.75
Winter period	wh	7.5/3.5	12.50	92.81	40.25
Interim sum labour costs				*173.25*	*115.00*
Fixed costs		%	€		
Annuity stable/stall		6	1 100	85.19	35.98
Maintenance stable/stall		1.5	1 100	16.34	6.90
Interim sum fixed costs				*101.52*	*42.88*
Total costs				923.61	825.00
Market performance	**Unit**	**Quantity**	**Price per unit**	**Earning (€/ha)**	
Proportional market performance			€		
Heifer	kg CW	44.7	1.70	75.23	69.91
Bull calf	kg CW	86.6	2.40	205.76	191.21
Culled cow	kg CW	65.5	1.50	97.27	90.39
Sum market performance				378.26	351.51
Contribution margin I (without subsidies)				67	52
Contribution margin II (without subsidies)				–271	–316
Calculated profit/loss (without subsidies)				–545	–473

Table 8.5. *Continued*

Suckler cow – feeder cattle production **Number of suckler cows per ha**				**Winter stable 0.99**	**No stable 0.92**
Expense factor	**Unit**	**Quantity w./no stable**	**Price per unit**	**Result (€/ha)**	
Direct payments			€		
Suckler cow premium	Animal	1	200	198.00	184.00
Low stocking premium	Animal	1.455	100	144.05	133.86
Slaughter premium + supp. cow	Animal	0.17	100	16.83	15.64
Slaughter premium + supp. bull	Animal	0.455	100	45.05	41.86
Slaughter premium + supp. heifer	Animal	0.285	100	28.22	26.22
Sum direct payments				*432.14*	*401.58*
Agri-environmental payments			€		
for nature conservation (HEKUL)	ha	0.39/0.47	90	34.75	38.92
for landscape maintenance (HELP)	ha	0.62	260	159.59	148.30
Less favoured area compensation	ha	1.01/1.09	46	46.00	46.13
Sum agri-environmental payments				*240.33*	*233.35*
Sum total earnings				1 050.73	986.44
Contribution margin I (with subsidies)				739	686
Contribution margin II (with subsidies)				402	319
Calculated profit/loss (with subsidies)				127	161
Percentage proportion market performance of total earnings				36	36

plus winter forage), the values happen to almost agree with those per animal. This relationship is subject to specific area productivity, which in the case of the pasture is so low that one can assume a high potential for nature conservation.

Suckler cow keeping – description of the procedure variants

Breed: German Simmental; stock size: 100 suckler cows; grassland used within extensification rules: pasture net yield 40 000 MJ ME, meadow net yield 57 000 MJ ME, 0.91 raised calves per suckler cow, restocking every 6 years, feeder cattle production, target weight: heifers: 280 kg LW, steers: 340 kg LW, slaughter weight, old cow: 700 kg LW.

Procedure 1. Seasonal grazing with winter stable keeping, deep litter house; 180 grazing days, 185 stable days; land use: pasture – 0.63 ha; meadow – 0.39 ha; stocking density 0.99 suckler cows per hectare (corresponds to about 1.3 livestock units (LSU) per ha).

Procedure 2. Seasonal grazing with winter free range keeping, cattle shed; 180 grazing days, 185 winter feed days; land use: pasture – 0.63 ha; meadow – 0.47 ha; stocking density 0.92 suckler cows per hectare (corresponds to about 1.2 LSU ha^{-1}).

The variable costs for both procedures are very close at about €300 ha^{-1} yr^{-1} (Table 8.5). The green forage costs are about €340 and €370 respectively per hectare per year. With regard to the labor costs, a work time requirement per animal is assumed which reflects efficient conditions and is clearly under the figures given by most professional literature sources. This together with the low stable costs (in the case of winter outdoor keeping, a low-cost cattle shed is set up) means that the total costs are underestimated rather than overestimated and the economic viability of the procedure ceteris paribus for the Rhoen is represented as too favorable rather than too unfavorable. In this way, the principle of being on the 'safe side' can be asserted – one can say that suckler cow farming in the Rhoen and in comparable low mountain range areas is ceteris paribus at least as expensive as is calculated in the tables. Also, one can say that the calculation results have a claim to validity also under more favorable local and agri-structural conditions.

The total costs for the winter stable keeping are about €930 ha^{-1} yr^{-1} and for winter outdoor keeping, about €100 less. This compares with a market performance of about €380 and €350 respectively per hectare per year. Based on market data, winter stable keeping results in a yearly loss of about €550 ha^{-1}; for winter outdoor keeping, it is about €80 lower. One can say that society must subsidize this deficit (apart from overheads and leasing costs) if it wants landscape stewardship in this form. In actual fact, at the time of the investigation (2003), society paid even more, namely about €670 ha^{-1} yr^{-1} for winter stable keeping and slightly less for outdoor keeping in winter. Therefore, the assumed model enterprise produces a yearly excess of €127 and about €160 ha^{-1} yr^{-1} respectively, which is available to cover the omitted leasing and overhead costs. Admittedly, a large part of this support consists of direct payments per animal independent of the ecological benefit of grazing and represents therefore a purely income-orientated subsidy for beef production – along with all the economic question marks which arise from such subsidization. Only the low stocking premium, the agri-environmental premiums from the HEKUL and HELP programs, and with qualifications, the LFA compensation payments, can be considered as reward for ecological services.

In spite of the high level of support, suckler cow farming in the low mountain range areas in 2003 is preferred by farmers considering leaving the industry as a way of further using existing buildings from earlier dairy farming processes, with reduced labor and investment input. Investment in new stables would probably occur in only a few cases.

Bullock Fattening

Calculations for the bullock fattening procedure based on the same plan as in Table 8.5, show that an even higher loss than for suckler cow farming can be expected, calculated on market data which give higher earnings but also significantly higher total costs.

Bullock fattening

Breed: German Simmental; stock size 80 to 100 animals; fattening from 125 kg; fattened weight 550 kg LW; daily gain 700–800 g; duration about 19 months; slaughter age about 23 months.

Grazing-pre-fattening – stable fattening – grazing and fattening; winter stable keeping 270 days; 320 days pasturing on extensive grassland: pasture net yield 40 000 MJ ME, meadow net yield 57 000 MJ ME.

Land use: pasture – 0.41 ha; meadow – 0.14 ha; stock density about 1.82 animals per ha (corresponds to about 1.27 LSU ha^{-1}).

This is compensated for with high direct payments per animal. If, as is assumed here, on top of this, grassland is farmed following HEKUL rules, the procedure makes a profit of €170. Whereas most cost positions correspond to the situation for suckler cow farming, the high costs of purchasing animals make a clear impact. It is not necessary to give here a detailed description in table form; a summary of all procedures included is available in Table 8.8.

Bullock fattening is not often carried out as a stand-alone farming activity but more often as part of a wider production system with dairy cows or suckler cows in order to utilize residual land. If this is to remain so in the future, then there are problems with the calculation in the area of fixed costs. One can assume that present-day bullocks use not only surplus grassland but also surplus stable space, making the full cost calculation questionable. Outdoor keeping in winter is not an option because of the associated weight losses; occasional periods of pasturing are also a necessary measure to prevent early fat formation. It can be summarized that the economic viability of bullock fattening at best corresponds approximately to that of suckler cow keeping.

Heifer Rearing

This branch of production brings a profit for the assumed data of about €300 $ha^{-1} yr^{-1}$ without financial support, in contrast to those previously discussed (Table 8.6), and this increases to about €550 mainly through agri-environmental premiums. This fact justifies a more detailed look at this branch, seriously neglected in discussions on nature conservation. It concerns a production branch secondary to dairy cow keeping which regularly needs young animals regardless of restocking times. If, for example, each dairy cow achieves four lactations, then there has to be a two-year-old heifer for every four dairy cows, plus the younger animals. There were and still are historical and regional differences in the systems for the keeping of young animals; as well as keeping by the farmer in his own farm, there were and are now variable labor-sharing models in which the young animals are raised by specialist enterprises or by cooperatives.

It is important to understand how the favorable results in Table 8.6 are arrived at. They assume a work division model in which both the calf and the heifer in calf are acquired and sold at market prices. If the total cost per hectare is recalculated based on the animal, it turns out that the heifer, with 2 086.44/2.3 = €907.15, has just as high costs as a suckler cow. The reasons are the calf costs and the circumstances that the labor requirement is not inconsiderable, at eight hours per animal.

Heifer rearing

Breed: German Simmental; from 125 kg; first calf age 27 months; raising duration about 24 months; calving at about 520 kg LW; average daily gain 550 g.

Winter stable keeping 360 days; summer pasture 370 days; use of extensive grassland: pasture net yield 40 000 MJ ME, meadow net yield 57 000 MJ ME.

Land use: pasture – 0.29 ha; meadow – 0.15 ha; stock density about 2.3 animals per ha (corresponds to about 1.29 LSU ha^{-1}).

Table 8.6. Full cost calculation for a heifer rearing procedure (number of young cattle per hectare: 2.3)

Expense factor	**Unit**	**Quantity**	**Price per unit**	**Result (€/ha)**
Variable costs			€	
Stocking	Heifer	1.0	363	834.90
Feed concentrate	dt	2.5	12.50	71.88
Mineral feed	at	0.18	45	18.63
Stud fee			20	46.00
Vet/medicines			35	80.50
Insurance			6	13.80
Energy/water/fuel			25	57.50
Bedding	at	15.0	3.50	120.75
Others			6	13.80
Interest on working capital	%	6.0		60.65
Interim sum variable costs				*1 318.41*
Costs fodder production			€/10 MJ	
Winter fodder (meadow)		8 335	0.13	249.22
Summer fodder (pasture)		11 510	0.02	52.95
Interim sum fodder production				*302.17*
Labour costs			€	
Pasture period	wh	1.0	12.50	28.75
Stable period	wh	7.0	12.50	201.25
Interim sum labour costs				*230.00*
Fixed costs		%	€	
Annuity stable		6	1 100	197.91
Maintenance stable		1.5	1 100	37.95
Interim sum fixed costs				*235.86*
Total costs				2 086.44
Market performance	**Unit**	**Quantity**	**Price per unit**	**Earning (€/ha)**
Proportional market performance			€	
Heifer sales	Heifer	0.9	1 100	2 277.00
Slaughter heifers	kg CW	29	1.70	113.39
Sum market performance				2 390.39
Contribution margin I (without subsidy)				1 072
Contribution margin II (without subsidy)				770
Calculated profit/loss (without subsidy)				304

Table 8.6. *Continued*

Subsidies	Unit	Quantity	Price per unit (€)	Remuneration (€/ha)
Direct payments			€	
Slaughter premium +supp.	Animal	0.1	100	23.00
Agri-environmental payments			€/ha	
for landscape maintenance (HELP)	ha	0.29	260	1 73.42
Less favoured area compensation	ha	0.44	46	46.55
Sum agri-environmental payments				*219.97*
Sum total earnings				2633.36
Contribution margin I (with subsidies)				1315
Contribution margin II (with subsidies)				1013
Calculated profit/loss (with subsidies)				547
Percentage proportion market performance of total earnings				91

The excellence of the procedure is a result solely of the very high market performance, that is, the high price for quality breeding heifers. In the table, it is realistically assumed that 10% of the animals cannot be used as dairy cows and must be marketed as heifers for slaughter. If there is a clear increase in this sector, then the viability drops strongly; pure meat marketing would lead to an even worse result than for bullock fattening. The favorable result for heifer breeding is therefore strongly dependent on the lively demand within the milk sector for heifers.

In the case that heifer rearing takes place in dairy farming, the overall calculation in Table 8.6 is admittedly artificial but the individual elements can be properly interpreted. The full rearing costs of an animal without the cost of the calf are about €550. If the dairy farm can cover the full costs of calf rearing as well as the calculated €550 per young animal from earnings – mainly from milk sales – then a situation arises in which the heifer grazing is carried out with nil costs. The fact remains that the grazing and associated landscape stewardship performances at about €500 ha^{-1} yr^{-1} are cheaper than for suckler cow farming.

Dairy Farming

As already mentioned, from the perspective of extensive grazing for nature conservation, milk production is interesting only indirectly because of the connection with the heifer rearing. However, an understanding of the economics as such is also of great significance. Milk production is only possible on intensively farmed land with high green forage output which is why there are differences in acceptance from the other production branches.

Table 8.7. Two variations for milk production in comparison

Dairy cow (DC) - milk production				**Sim-mental**	**Sim-mental**
Stock number				**40**	**120**
Number of cows per ha				**1.64**	**1.64**
Expense factor	**Unit**	**Quantity 40 DC/120 DC**	**Price per unit**	**Result (€/ha)**	
Variable costs			€		
Restocking	Heifer	0.2/0.25	907.15	297.55	371.94
Feed concentrate	dt	13.2/20	12.50	270.60	410.00
Mineral feed	dt	0.45	45	33.21	33.21
Stud fee			30	49.20	49.20
Vet/medicine			65	98.40	106.60
Insurance			20	32.80	32.80
Energy/water/fuel			70	114.80	114.80
Bedding	at	7/8	3.50	40.18	45.92
Others			95	155.80	155.80
Interest on working capital	%	6		34.39	39.10
Interim sum variable costs				*1 126.93*	*1 359.36*
Cost fodder production			€/10 MJ		
Winter fodder (meadow)	MJ ME	18 788	0.11	338.94	338.94
Summer fodder (pasture)	MJ ME	23 912	0.06	235.29	235.29
Interim sum fodder production				*574.23*	*574.23*
Labour costs			€		
Pasture period	wh	24/16	12.50	492.00	328.00
Stable period	wh	20/19	12.50	410.00	389.50
Interim sum Labour costs				*902.00*	*717.50*
Fixed costs		%			
Annuity stable		6	4 500/3 000	577.31	384.88
Maintenance stable		1.5	4 500/3 000	110.70	73.80
Interim sum fixed costs				*688.01*	*458.68*
Total costs				3 291.17	3 109.77
Market performance	**Unit**	**Quantity 40 DC/120 DC**	**Price per unit**	**Earning (€/ha)**	
Proportional market performance	kg/ha	9 344/11 639	€		
Milk sales	kg	5 700/7 100	0.34/0.26	3 178.32	3 027.44
Heifer calf (14 d.)	pcs.	0.45	80	59.04	59.04
Bull calf (14 d.)	pcs.	0.45	130	95.94	95.94
Culled cow	kg CW	82.5	1.50	202.95	253.38
Sum market performance				3 536.25	3 435.80
Contribution margin I (without subsidies)				2 409	2 076
Contribution margin II (without subsidies)				1 835	1 502
Calculated profit/loss (without subsidies)				245	326

Table 8.7. *Continued*

Dairy cow (DC) - milk production				Simmental	Simmental
Stock number				40	120
Number of cows per ha				1.64	1.64
Subsidies	**Unit**	**Quantity 40 DC/120 DC**	**Price per unit**	**Remuneration (€/ha)**	
Direct payments			€		
Slaughter premium +supp. Cow	Animal	0.2/0.25	100	32.80	41.00
Agri-environmental payments					
Less favoured area compensation	ha	0.61	46	46.02	46.02
Sum total earnings				3 615.07	3 522.82
Contribution margin I (with subsidies)				2 488	2 163
Contribution margin II (with subsidies)				1 914	1 589
Calculated profit/loss (with subsidies)				324	413
Percentage proportion market performance of total earnings				98	98

Milk production and calf production

Breed: German Simmental; restocking every 5 years (0.2 animals ha^{-1}); 0.9 calves per cow per year, 50% male, 50% female; calf sale at about 45 kg (male: about €130, female: about €80); Loose housing with manure removal and spread-straw pens; summer grazing 2 times daily; use of intensive grassland: pasture net yield 42 000 MJ net energy lactation (NEL) per ha, meadow net yield 42 000 MJ NEL ha^{-1}.

Procedure 1. Milk output 6 000 kg gross; space for 40 cows; basic ration output about 3 800 kg milk; Land use: pasture – 0.34 ha, meadow – 0.27 ha per cow; 1.64 cows per ha (= 1.64 LSU ha^{-1}).

Procedure 2. Milk output 7 500 kg gross; places for 120 cows; basic ration output about 4 000 kg milk; Land use: pasture – 0.34 ha, meadow – 0.27 ha per cow; 1.64 cows per ha (= 1.64 LSU ha^{-1}).

Unlike the other tables, Table 8.7 contains a comparison with an actual present-day procedure in which a relatively inefficient farm structure (40 dairy cows per farm, moderate output per cow) combined with a high product price (€0.34 per kg milk, produced under organic conditions), with expected future conditions characterized by higher efficiency (120 animals, higher output) but significantly lower product price (€0.26 per kg, produced under conventional conditions).

It is clear that both cases can achieve an excess of €250 to €320 ha^{-1}, that is, there is full coverage of all the costs of the procedure. As well as the non-inclusion of overheads, another point to note is the absence of estimates for quota costs. Because the most important agro-political instrument is in this quota regulation, the significance of direct support is very low.

Synopsis

This section introduces model calculations on the common forms of cattle farming with the goals of milk and beef production, with an explanation of the details and a discussion. Table 8.8 contains a summary of the results of the model calculation. The main points are:

- Milk production in technically efficient units and with an appropriate animal output covers its costs when a particular price level is present. This must be guaranteed if the production branch is to continue over the long run. However, dairy cows cannot utilize vegetation growth in grassland interesting from a nature conservation perspective, or can do so only to a small extent.
- The breeding of young cattle for dairy farming is profitable under the assumptions made here. For the combination presented here, the statement that a milk production which also covers the costs of the young cattle would allow a pasturing of zero costs can be mitigated. Two-year-old heifers that utilize lower-energy feed are a very interesting alternative.

Table 8.8. Most important figures for different production procedures for cattle farming in Euro

Position	Procedure					
	Suckler cows		Bullock fattening	Heifer rearing	Dairy cows	
	Winter stable	No stable			40 places	120 places
Variable costs	311	300	842	1 318	1 127	1 359
Green forage	337	367	244	302	574	574
Labor	173	115	187	230	902	718
Fixed costs	102	43	119	236	688	459
Proportional market performance	378	352	729	2 390	3 536	3 436
Direct payments	432	402	719	23	33	41
Agri-environmental premiums	240	233	113	220	46	46
Contribution margin I (without subsidy)	67	52	–113	1 072	2 409	2 076
Contribution margin II (without subsidy)	–271	–316	–358	770	1 835	1 502
Calculated profit (without subsidy)	–545	–473	–663	304	245	326
Contribution margin I (with subsidy)	739	686	719	1 315	2 488	2 163
Contribution margin II (with subsidy)	402	319	474	1 013	1 914	1 589
Calculated profit (with subsidy)	127	161	169	547	324	413
Percentage proportion market performance of total earnings	36	36	47	91	98	98

- All beef production procedures are greatly in deficit and are maintained only through financial support. They burden the grazing with high costs.

8.1.4
Sheep Grazing As an Alternative

A quick look at sheep farming here is justified for several reasons. In some low mountain range areas, it has played and continues to play a dominant role in the creation of species-rich and aesthetically attractive landscapes, such as the 'juniper heaths' in the Swabian and Frankish Mountains. Although they are found mainly on the limestone soil areas, they are not restricted to these alone; they occur as well in the Ulster Valley in the Rhoen project area. Parts of the High Rhoen and the investigation area in Thuringia are grazed by roaming flocks (transhumance sheep flocks and stationary herded keeping). Sheep grazing systems have also been scientifically researched in some detail (see Beinlich and Plachter 1995) and the economic basis is largely understood (see Hampicke and Tampe 1995; Tampe 1995; Tampe and Hampicke 1995 in the listed volume as well as Beinlich et al. 1997).

With respect to the forms of keeping, there is a distinction made between paddock keeping, roaming flocks and herded flocks. The first is not an option because of its high intensity regarding landscape management objectives. The opposite is the case for the second type; it is perfectly suitable for dispersion of plant and animal diaspores, particularly through the mobility of the sheep (Fischer et al. 1995), but for various reasons, there are increasingly fewer farmers. Traffic routes are lacking, particularly because streets are cut across sheep trails. Winter pastures in mild lowland areas are no longer available and the sheep which are suitable for the effort of roaming are becoming increasingly rare. Therefore, stationary herded sheep farming represents an optimal compromise in which the flocks are herded on large-scale droves which are interconnected as far as possible, and are driven over many kilometers but spend the winters in stables in the same area.

The production target of present-day sheep farming in Central Europe is almost exclusively the production of lambs for slaughter; generally, the resulting wool only covers the shearing costs. The breed of sheep is decisive in the quality of the meat; there are demanding breeds such as Merino and Black-headed Sheep which are farmed. Milk sheep require an intensive form of keeping and are therefore not considered here. The Sect. 8.1.6 deals with particularly less demanding special breeds.

Because of the traditionally low demand for sheep meat in Germany as well as the high import pressure from, for example, New Zealand, the market for sheep meat is affected by a pressure on prices similar to that in the beef market, with corresponding consequences for the viability of the production branch.

Table 8.9 compares the economics of two herded sheep flocks in Baden-Württemberg and Thuringia. Both cases deal with actual farms, unlike the theoretical examples used for the model calculations in Sect. 8.1.3. Set against the advantages of using a real situation are the disadvantages that not all of the figures can be properly

Table 8.9.
Economics of herded sheep farming according to two studies (€ ha^{-1} yr^{-1})

	Tampe and Hampicke 1995	Hampicke and Roth 2000[a]
Variable costs	335.20	205.54
Labor costs	251.56	295.02
Fixed costs	198.38	131.91
First maintenance[b]	122.71	–
Pasture management	25.56	–
Market performance	397.44	178.44
Contribution margin	62.24	–27.10
Profit /loss	–536.97	–454.03
Subsidy[c]	329.27	No data
Profit/loss after subsidy	–207.70	No data

[a] Data collected by W. Berger. Thuringia's Institute for Agriculture. Jena.
[b] Perpetuity for an initial investment of € 2 045 for bush removal.
[c] Baden-Württemberg 1995.

compared. It is also not certain whether the observed farms are as efficient as was assumed for the model calculations for cattle farms described above. However, it can be accepted that both calculations reflect typical conditions and the scale of the economic parameters are correctly ascertained.

In the procedure in Baden-Württemberg, there is a stocking density of 4 ewe units per hectare on calcareous soils and in Thuringia there are only 2.3 units per hectare. This is because the market performance and the variable costs are considerably higher per hectare in the first case. The reason for this difference is not so much the higher stocking density in Baden-Württemberg but more so the circumstances that for computing reasons, all costs and earnings relate to the calcareous grassland and not to the winter-feed land which is also needed. The sum of fixed and labor costs is almost the same in both examples. In Baden-Württemberg, the costs of the first maintenance work to the pastureland, which had taken a lot of time, have to be included. In addition, certain costs arose from works of pasture management.

The considerably higher total costs per hectare in Baden-Württemberg are compensated for by high market performance so that in both cases there is a total shortfall or a lack of financial support in the region of €500 ha^{-1} yr^{-1}. A significant proportion of this negative result is a consequence of the high labor input of 32.8 and 27.1 h ha^{-1} in Baden-Württemberg and in Thuringia respectively. It is therefore rather incorrect to speak of an 'extensive production branch' for herded sheep farming. Extensive production branches are those which require low input, including low labor per hectare of land. The labor requirements per unit of land in sheep farming according to the figures presented here are about four times as high as for cropping with highest yield grades and almost twice as high as an efficient suckler cow enterprise. On top of this, the work requires a high level of competence and there are work peak periods such as during the lambing time.

Even allowing for the imperfections in the examples used here, it is still clear that the hope of achieving cost savings through a transition from beef to lamb production is an illusion.

8.1.5
Comparisons with Values from the Professional Literature

The production branch analyses presented here have partly been published separately by the authors (Rühs et al. 2005). There were minor differences in assumptions which were made and in the results, which on the whole remain within the field of accuracy of the basic data. Table 8.10 shows a summary of the economic data on grazing procedures from the professional literature. Most of the data relates to suckler cow farming but there is also information on beef heifers, breeding heifers, bullock fattening and flock keeping of sheep and goats. An exact comparison of the research in which every detail of the survey must be tested in order to guarantee compatibility is very time-consuming. Not all authors describe their calculations so detailed that the results can be properly understood. Thus, incomplete costing can be the cause of small deficits; in particular, the methodology applied to fixed costs frequently leaves a lot to be desired. In some of these works, the element which constitutes financial support is not clearly indicated.

One can see that for breeding heifers positive results can be achieved even without subsidies. In agreement with this work, on the other hand, negative results can occur with procedures in fattening of beef heifers, even if not to the extent calculated here. The more favorable results are a consequence of the following causes, so far as there are no deficiencies in costing:

- Older investigations are based on the more favourable beef prices of that time.
- The best sales conditions were present during the time before the BSE crisis in 2001 when numerous suckler cow herds were built up and the resulting demand for meat breed livestock supported very high prices.
- With the best farm-structural and natural conditions, suckler cow farming, particularly on lowland, can actually be more economical, especially with advantageous sales opportunities.
- Several investigations relate to low-yielding sites which are discussed in the following section under 'Alternative III'.

It should be underlined here that investigations using outstanding methodologies, such as by Roth and Berger (1999) as well as Berger (2001), have arrived at very similar results as the study presented here. A glance at the current calculation basis of the KTBL (2004), however, should not be omitted. There, the labor requirement for a suckler cow with calf (including fence repairs) was set at 24 h yr^{-1} (p. 416) instead of 14 h (with winter stable keeping) and 11 h (with outdoor winter keeping) respectively in Table 8.5. This comparison alone shows that the costs of suckler cow keeping in the study presented here are certainly more underestimated than overestimated. The planning data given in the above-mentioned KTBL publication for sheep farming (labor requirements, variable and fixed costs, pages 417–427) agree broadly with those in Table 8.9.

Table 8.10. Comparative overview of the performance and cost structure of different livestock procedures relative to hectares, according to various sources. All information in Euro; *n.d.:* no data. Sources: *1:* Bezirksregierung Mittelfranken 2000; *2:* BMLFUW 2002; *3:* Gräfe 2002a; *4:* Harms 2002; *5:* LFL 2001; *6:* Martin 2001; *7:* Titze and Martin 1999; *8:* Hochberg and Neubert 1999; *9:* Piehl 2000; *10:* Roth and Berger 1999; *11:* Berger 2001; *12:* Manthe 2002; *13:* Karwath et al. 1997; *14:* Scharf and Redelberger 2002; *15:* Gräfe 2002b; *16:* Weber and Piehl 2001; *17:* Gottensträter 2003; *18:* Klemm and Diener 2000; *19:* Tampe and Hampicke 1995; *20:* Prochnow and Schlauderer 2002; *21:* Korn 2001

Production		Total costs	Market earnings	Profit/loss		Source
Branch	Method			With subsidies	Without subsidies	
Heifer breeding and fattening	Quality breed	2 255	3 098	n.d.	843	2
	Dairy heifer	1 786	2 254	n.d.	469	2
	Dairy heifer	1 400	1 499	120	99	4
	Dairy heifer (calving age 30 m.)	1 525	1 697	189	171	5
	Breed suckler (calving age 24 m.)	2 023	2 090	n.d.	67	6
	Breed suckler (calving age 36 m.)	2 535	2 090	n.d.	–445	6
	Heifer fattening (90 to 600 kg)	2 619	2 021	n.d.	–597	1
	Heifer fattening (95 to 520 kg)	2 314	2 005	n.d.	–309	2
	Heifer fattening, conventional (90–410 kg)	1 102	515	–458	–588	3
	Heifer fattening, organic (90–410 kg)	1 247	593	–524	–654	3
Suckler cows	On fen (calving age 24 m.)	737	414	16	–323	7
	On sand (calving age 36 m.)	371	178	–23	–193	7
	Cattle shed (calving age 24 m.)	601	400	147	–201	7
	Open stable (calving age 24 m.)	611	436	159	–175	7
	Outdoor winter feeding (calving age 36 m.)	720	375	1	–345	7
	Year round grazing (calving age 36 m.)	683	356	21	–326	7
	100 to 150 animals	663	318	–61	–345	8
	Winter stable	885	844	87	–41	9
	Year round grazing	660	640	107	–20	9
	Mountain grazing, winter stable	919	376	–402	–543	10
	Mountain grazing, outdoor keeping	673	340	–206	–333	10
	Winter stable	828	231	–37	–597	11
	Landscape maintenance w. Heck cattle	257	0	–187	–257	12
	Winter stable	994	701	118	–292	5
	Outdoor keeping	883	701	229	–182	5
	Deep litter house	657	343	–137	–314	13
	Low hutch	594	343	–73	–251	13
	Outdoor keeping	474	314	18	–160	13
	German Simmental fatteners	1 235	889	n.d.	–345	

Table 8.10. *Continued*

Production		Total costs	Market earnings	Profit/loss		Source
Branch	Method			With subsidies	Without subsidies	
	Charolais fatteners prod.	1 152	1 101	n.d.	–51	
	Angus fatteners prod.	1 411	961	n.d.	–450	
	German Simmental fattening	1 524	1 122	n.d.	–402	
	Charolais fattening	1 542	1 244	n.d.	–298	
Bullock fattening	90–610 kg LW	3 257	2 320	n.d.	–937	1
	50–500 kg LW	1 862	856	143	–1 006	5
	Empirical data from north-east Germany	1 768	877	124	–891	9
	Conventional, 200–600 kg LW	1 775	780	–556	–996	3
	Organic, 200–600 kg LW	2 035	897	–479	–1 139	3
	100–650 kg LW	2 277	1 822	n.d.	–455	2
Bull fattening	90–660 kg LW	3 507	2 778	–4	–729	1
	180–660 kg LW	4 154	3 333	49	–821	1
Milk production	5 800 kg eco-milk	2 528	2 931	643	404	14
	8 000 kg conv., Germ. Simmental	4 851	4 793	n.d.	–58	1
	8 000 kg conventional	3 435	3 478	221	42	15
	8 000 kg conventional, Holstein-Friesian	3 158	3 527	414	369	5
	7 800 kg conventional	5 676	6 941	1 265	n.d.	16
	9 000 kg conventional	6 361	7 315	954	n.d.	17
Sheep	Ewes 500 units	87	41	19	–47	18
	Stationary herding	785	397	–58	–388	19
	Ewes 500 units	499	143	–314	–355	10
	Ewes 300–350 units	798	231	–502	–567	10
	Ewes on Military Training Area	292	20	–89	–272	20
Goats	Landscape maintenance	340	72	–90	–269	21
	Milk goats (cream cheese production)	1 411	1 399	90	–12	22

Sources: *1:* Bezirksregierung Mittelfranken 2000; *2:* BMLFUW 2002; *3:* Gräfe 2002a; *4:* Harms 2002; *5:* LFL 2001; *6:* Martin 2001; *7:* Titze and Martin 1999; *8:* Hochberg and Neubert 1999; *9:* Piehl 2000; *10:* Roth and Berger 1999; *11:* Berger 2001; *12:* Manthe 2002; *13:* Karwath et al. 1997; *14:* Scharf and Redelberger 2002; *15:* Gräfe 2002b; *16:* Weber and Piehl 2001; *17:* Gottensträter 2003; *18:* Klemm and Diener 2000; *19:* Tampe and Hampicke 1995; *20:* Prochnow and Schlauderer 2002; *21:* Korn 2001.

8.1.6
Alternatives

Meat Production

The calculations given above show that agriculturally-orientated grazing with the objective of producing meat is an expensive production process in all its forms. The following costs accrue:

- variable costs per animal, which remain considerable even after all saving possibilities have been exhausted
- costs for green forage, arising from the particularly expensive supply situation for winter fodder in the low mountain ranges which cannot be rationalized away (this is an economic disadvantage of the location compared to locations near the coast, or countries with low seasonal variations)
- costs for labor, described in detail above, and
- investment costs (fencing, stables, shelters) which cannot be reduced under a minimum even with extreme saving measures

As already mentioned, the topical description 'extensive production branch' is out of place here as the total expenditure per unit of area is high. Only the expenditure on fertilizers and plant protection is close to or at zero, out of which the compatibility with nature conservation is a result. Significantly, the production factors which are saved or left out belong to the relatively least expensive, while the most expensive production procedures involving labor are called on to a large extent.

Set against the high costs are low earnings, determined through low meat prices. As a rule, the production branches are only operated because they (still) command a high subsidy. Also, many enterprises forego a full coverage of costs; there is scope for a temporary deficit regarding fixed costs, a clear foregoing of the covering of fixed costs in expiring farms as well as for a lower payment for labor than is assumed in the calculations.

Apart form the last-mentioned, unsatisfactory alternative, only a higher payment for the product can reduce the cost excess and therefore the need for subsidy. This takes place successfully with direct marketing. Even when this can lead to further increases in costs, significantly higher product prices bring about better account balances or even a full coverage of costs. There is however no doubt that direct or quality marketing can only encompass a quantitatively small market segment and probably cannot be considered as an alternative for many wide pasture regions. This raises the question about basic alternatives.

Alternative I: Breeding Heifers

This procedure has been attracting increasing interest, not least with regard to future agro-structural policy (see Sacher et al. 2006 and the other contributions in this work). It is described in more detail in Table 8.6 and economically is very positively evaluated.

The first box in Table 8.10 shows that this view is also supported in the professional literature. A comparison of Table 8.5 and 8.6 shows that the cost advantage of young cattle breeding over suckler cow farming is not decisive. Because instead of keeping a suckler cow, more than two young cattle per hectare are kept, the livestock-related costs per unit of land are doubled. The economic benefits of the procedure consist mainly of a well-paid product, so long as it is a quality heifer sold for breeding purposes for milk production. That is the economic difference between beef and breeding heifer production: in the first case, the product is badly paid and the necessary grazing element carries high costs. In the second case, the procedure carries itself and grazing takes follows as a cost-free co-product.

Of course, it is not automatic that the heifers which are sold can completely cover the breeding costs. The success of the procedure is dependent on a lively demand in the dairy sector for heifers. This is, among other things, affected by the restocking rate; long-living cows, which is in itself a positive thing, lead to a lower demand. For a given amount of produce, the increase in milk yield per cow has the same effect. However, the key point for the situation in peripheral regions is in fact the extent of milk production; the hypothetical retirement of this branch in a region would make heifer breeding redundant. This extremely important question will be returned to at the end of this chapter.

Against the suggestion of integrating dairy industry breeding more strongly into landscape management, various reservations are raised in practice. They are valid to the extent that a target-oriented system of nature conservation grazing can require additional costs and therefore is disadvantaged compared to the cheapest alternative of keeping young animals in a stable or on intensive pastures near the farm. A breeding heifer can be taken to pasture at eleven months; if that is to happen, then age and season have to be in agreement. They are inseminated at 15 to 19 months, which can require transport. They calve at the age of 24 to 27 months; becoming dairy cows then.

It is clear that every heifer is capable of pasturing for about a year and it should be possible with sufficient organization to use at least a part of this potential. It is also clear that they also have specific requirements with regard to green forage quality and do not want poor calcareous grasslands (see Dierchen 2006). There is an as yet completely unused potential for farm subsidies with the objective of compensating willing enterprises for the additional expenditure of heifer breeding with grazing performances oriented to nature conservation. This financial support – perhaps for separate winter feed chains for dairy cows and breeding heifers – would in all likelihood require a fraction of the resources needed to cover the deficit arising from suckler cow keeping.

Another worthwhile task which is equally unperceived is the support of cooperative organization forms of work-sharing, which still function in some areas, in which also large distances between farms keeping cows and those breeding heifers can be surmounted. Concerns arising over animal hygiene or other issues could be overcome with suitable precautions; the importance of a pasture offering a wholesome and adequate amount of movement for heifers is valued by dairy farmers. The considerations here underline the large indirect significance that a prosperous (at least covering costs) future milk production in Central Europe can have for grazing oriented to nature conservation.

Alternative II: Semi-Open Pastureland through the Farming of Semi-Wild Livestock

For several years, there has been a lively discussion about using grazing regimes with livestock having some of the characteristics of wild animals to maintain semi-open landscapes (Bunzel-Drüke 1997; Bunzel-Drüke et al. 1995; Riecken et al. 1997; overview in Redecker et al. 2002). A much-discussed example is that of the Heck cattle herds in Oostvaardersplassen, Netherlands, where experiments also took place in which animal cadavers were left on the rangeland to promote biodiversity. The overall concept is one of a landscape shaped more or less by wild herbivores.

The opportunities and problems arising from such systems have been described in detail by Kampf (2002). Veterinary hygienic controls and animal protection rules play an important role and carry strict conditions, unlike in the case of animals subject or otherwise to hunting laws. The economics of these systems is characterized by a foregoing of production with at the same time, a minimization of effort. There are no significant economic calculations. Because it would probably lead to difficulties in integrating such systems in a traditional, small-scale low mountain range's landscape oriented to tourism, this alternative is given no further consideration in the work presented here.

Alternative III: Semi-Open Pastureland through Landscape Stewardship

This variant of semi-open grazing is differentiated from the use of semi-wild livestock in that the land is farmed as extensively as possible but the rules affecting agricultural livestock farming are complied with. It is therefore burdened with the unavoidable costs of managing the animals. Experience up to now indicates that this model integrates well into the low mountain range's landscape; a large-scale and very promising example is discussed by Reisinger and Lange (2005).

Just as in grassland biotopes where mowing is occasionally used solely to help preserve a naturally valuable cut meadow community and for which the value of the product is negligible (through the need for disposal, even negative), there are also in extreme cases grazing regimes which are carried out for the sake of the pasture grazing and not for production purposes. However, the dividing line with product creation is fluid; often, a generally modest production can take place. Typical stewardship uses of this kind include undemanding sheep breeds, Skuddes, Heck cattle, Fjäll cattle and Galloways, Icelandic horses, Konik horses, goats and wild goat species.

An economic study runs up against several difficulties. The number of applicable keeping systems is not very high. Landscape stewardship keeping in large protected areas and many other places is operated with mixed financing schemes and regularly complemented by unpaid work and subsidies. Forestry and other workers are brought in to assist during periods of low employment and occasionally, as is reported, workers are paid in kind. Thus a clear cost-performance analysis is difficult to carry out. For keeping systems which have only been around for a few years, it is doubtful as to whether income statements represent the long-term or are only momentary indicators. Surveys also suffer from the typical lack of interest in economic questions shown by most of those involved and the numerous contributions about grazing regimes in Redecker et al. (2002) contain hardly any economic information.

The data presented by Prochnow and Schlauderer (2002) as well as from Schlauderer (draft) concerning stewardship systems for keeping land open on former military training areas are very relevant in this connection. They are shown in compressed form in Table 8.11. To allow for comparison, the first and second lines show the respective values from the tables of the investigation presented here (suckler cow, conventional: procedure with winter stable keeping, Table 8.5; herded sheep, conventional: average values from both investigations from Table 8.9).

For the procedure 'Galloway T' (T for military training area), 180 Galloway cattle and five Konik horses (not considered here) were kept on 260 ha of the former military training area known as Harrisleer Heide at a density of 0.42 cattle per hectare. The labor costs per animal are greater than for conventional suckler cow keeping but because of low costs for winter fodder, buildings etc. the total costs per animal are around 1.5 times those for herded sheep and 0.42 times for conventional suckler cow keeping. In the information listed, the costs for livestock and restocking are absent. The total cost per hectare are diluted because of the very low stocking density and amount to €164 ha^{-1} yr^{-1}, less than 20% of the level for conventional suckler cow keeping. This dilution is necessary because of the low productivity of the site (poor soils, *Calluna* heath etc.). On the same area as for conventional comparative procedures, at least 1.3 Galloway cattle per hectare would have to be grazed because of their much lower feed requirements, which increased the total area cost even without taking into account the livestock, by over €500 ha^{-1} yr^{-1}.

With regard to the research by Prochnow and Schlauderer (2002) into sheep farming on military training areas, labor and total costs per animal were on average within the same range as for conventional herded sheep farming. Because of extremely low stocking densities of 1–1.5 ewes per hectare on the poor soils, the cost per unit area is considerably reduced. The outputs per unit of area are so low that the procedure can be seen as nutrition purely for stewardship grazing without production purposes. The cost over-run of €255 ha^{-1} yr^{-1} is relatively low only because of the low stocking density and for a density as in conventional procedures (line 2), would exceed the indicated levels.

The last line in Table 8.11 shows that a deer enclosure with red deer, fallow deer and mouflons as well as Iceland horses leads to a cost shortfall of only about €130 ha^{-1} yr^{-1}.

Table 8.11. Cost comparison for livestock farming on military training areas (*T*) with conventional keeping (€ ha^{-1} yr^{-1})

	Labor costs per animal	Total costs per animal	Total costs per ha	Performance per ha	Result per ha
Suckler cows, conv.	175.00	932.94	923.61	378.26	–545.35
Herded sheep conv.	95.58	255.17	782.94	287.94	–495.00
Galloway T	284.00	394.81	164.00	74.00	–90.00
Sheep T	79.50	211.50	280.00	24.50	–255.50
Wild animals T			156.44	25.00	–131.44

Source: Prochnow and Schlauderer 2002, Schlauderer (draft).

Table 8.12. Procedure costs in grazing projects with agricultural livestock (€ ha^{-1} yr^{-1})

	ERNA	Lippeaue	Wulfener Bruch	Verchen	Schäferhaus	Lämmerhof
Variable costs	78.46	74.55	57.76	42.95	44.91	50.63
Labor costs	119.71	79.78	198.00	93.15	96.36	27.32
Fixed costs	40.69	56.75	33.54	18.26	18.15	42.44
Procedure costs	**238.86**	**211.08**	**289.30**	**154.36**	**159.42**	**120.39**
Market performance	0.00	102.18	150.00	0.00	67.31	73.08
Results	**–238.86**	**–108.90**	**–139.30**	**–154.36**	**–92.11**	**–47.31**

ERNA: Schleswig-Holstein, Heck cattle, 83 ha. *Lippeaue:* North-Rhine Westphalia, Heck cattle and Konik, 180 ha. *Wulfener Bruch:* Sachsen-Anhalt, Heck cattle and Przewalski horses, 65 ha. *Verchen:* Mecklenburg-Vorpommern, Heck cattle and Tarpan, 110 ha. *Schäferhaus:* Schleswig-Holstein, Galloway and Konik, 260 ha. *Lämmerhof:* Schleswig-Holstein, Angus, 65 ha. More details in: Kaphengst et al. 2005.

If one equates the livestock kept on the land with estimated values for agricultural livestock units, a stocking density of only about 0.25 LSU ha^{-1} results. The procedure is therefore only suitable for particularly low productive sites. One can again reckon a cost shortfall as for conventional suckler cow and herded sheep farming in the case of a fourfold increase in deer densities to 1 LSU ha^{-1} (disregarding the keeping practicalities).

Kaphengst et al. (2005) investigated six projects in which a semi-open pasture landscape was developed through the keeping of Heck cattle and other animals. In contrast to Prochnow and Schlauderer (2002), highly productive sites with dense vegetation are also found here in which the canopy cannot be completely utilized because of the low stocking densities of between 0.25 and 0.6 livestock units per hectare. Questions arising on the long-term development of such biotopes are not part of this work.

The performances of the project (stripped of all subsidies) are listed in Table 8.12. All are negative, as would be expected, although the deficits are clearly lower than for conventional agricultural keeping, similar to those of Prochnow and Schlauderer (2002), again mainly because of the low stocking density. One can more or less assume a procedure deficit in the area of €50–€250 ha^{-1} yr^{-1}.

The authors point out that some of the results must be seen as not completely confirmed. The operators of the projects are certainly enthusiastic nature conservationists but are not much in tune with the economic details and therefore the data structure has to be observed over the long run. Such projects which have improved their results through market performance stand before great uncertainties with regard to the future demand for the meat of Heck cattle.

Synopsis

The production of beef and mutton with conventional grazing regimes comes out with a minus of about €500 ha^{-1} yr^{-1} in the cases investigated here and ceteris paribus would always have a deficit of several hundred Euro with full costs even under favorable conditions. A consideration of grazing alternatives shows the following results:

- The breeding of heifers is economically attractive and justifies a more thorough consideration of future milk production systems in Central Europe, even if the dairy cows' pastures can have no value in respect of biodiversity. The grazing and associated biotope management using young cattle is without cost and may even make a small profit.
- The non-agricultural keeping of large herbivores such as in Oostvaardersplassen is difficult to adapt to the relatively densely populated cultural landscapes of the low mountain ranges and therefore cannot be considered as a large-scale alternative. Additionally, there are no robust findings on the economics of this.
- The economic understanding of landscape stewardship grazing with agricultural livestock is better, but not complete. Data collected mainly from military training areas indicate that low costs per hectare are very largely a consequence of low stocking densities which are adapted to the limited productivity of the area. Put simply: for the costs per animal are known and nearly fixed, the fewer animals that are kept per area, the lower are the costs per area. To what extent procedures with this cost advantage can also be kept over the long-term on highly productive sites, as is currently carried out in a few grazing projects, only time will tell. The procedure deficit and the associated landscape stewardship costs lie between €50 and €250 ha^{-1} yr^{-1}.

8.1.7
The Future

It can justifiably be objected that the calculations carried out here only give a snapshot impression and the profit and loss balance of the observed enterprises could change in the future.

Market Data

At the end of 2006, the price of beef was about 25% higher than the price prevailing during the investigation period in the Rhoen area (slaughter price for young bulls at €3 per kg carcass weight (CW), according to Bauernzeitung (2006)). This is at least in part due to 'decoupling' of farm subsidies (see below). This means that the deficit in suckler cow keeping shown in Table 8.5 is about €100 ha^{-1} yr^{-1} lower if all other figures remain unchanged. The result is still deep into the red.

Subject to the uncertainty of the outlook, one can assume that even with a normal sales situation – particularly with an absence of crises of the BSE (bovine spongiform enzephalopathy) type – the prospect of a major rallying of the price of beef to the extent that the procedures in Table 8.5 become profitable is unlikely. In the table with outdoor keeping (right column), the average beef price would have to rise by over 140%, all other conditions remaining equal, before the deficit of €473 ha^{-1} yr^{-1} would disappear. Conceivable trends such as this would induce a huge increase in imports which would in turn put downward pressure on prices. In Germany, imports would impact against a considerable potential for necessary beef production as a co-product of the dairy industry – that is, against a high 'basic quantity'. Moderate price rises in excess of those documented above are of course conceivable (and from the viewpoint of conservational grassland use, desirable), particularly with a growing consumer awareness of quality with respect to cattle breeds and regional origin. The future of milk production in the EU, and particularly in Germany, is clearly characterized by great uncertainty although there is a core of security regarding expectations. A relatively secure factor is the future domestic consumption of fresh milk products. Because this 'fresh segment' – estimated at a third of total consumption (Isermeyer 2002) – has limited transportability, there will continue to be a future fresh milk production close to the consumers in which 'close' includes neighboring countries but not, for example, countries such as New Zealand. At least, the price of goods in the fresh segment (plus domestic name-brand products such as types of cheese) can therefore achieve a degree of freedom from world market price influences; in other words, there will always be a more or less cost-covering dairy cow industry, even though probably to a lesser extent than today. Therefore, the conditions referred to above in which the breeding of young cattle for milk production is targeted to grazing strategies can be accepted in principle. However, conceivable structural changes that might occur remain to be regarded.

Subsidies

Changes in the agro-political subsidy regime have an indirect effect on the performance of the different procedures in that they induce price changes for factors and products; an example was referred to above. However, the direct income effects on farms through increasing and decreasing stock levels as well as the redefining of financial support have a far greater significance. The combination of suckler cow, extensification and slaughter premiums as well as remunerations from the HELP and HEKUL programs meant that in 2004, suckler cow farming and bullock fattening in the Rhoen could be carried out viably by individual farms, in any case, in the efficient (partly hypothetical) farm units listed in the tables. The system of financial support in the EU will, however, undergo major changes up to 2013 (more details in BMVEL 2005). The most important points are:

- *provisional farm premium ('combi-model')*: all price compensation measures (area payments for 'grandes cultures', particularly cereal and rape, all animal premiums) were abolished as from January 01, 2005. In Germany, a provisional farm payment at the same level of all previous compensation payments is paid which still allows the enterprise complete freedom to choose which type of product to produce ('decoupling'). In particular, farms which have received suckler cow premiums receive further amounts at this level even when they no longer keep suckler cows.
- *regional area payments*: sometime between 2009 and 2013, the available amount of financial support for direct payments will be gradually withdrawn and used for single area payments for arable land and grassland, in the region of €300 ha^{-1} yr^{-1}. This leads to considerable redistribution between enterprises. Whether the total amount of support will remain constant in the medium term after 2013 is questionable. Reductions and a general lowering of agricultural subsidy are not ruled out.
- *cross compliance:* as has been the case for a long time in Switzerland, single area payments and possibly other payments are only paid to the enterprises which through good agricultural practice meet defined environmental minimum standards.
- *modulation:* the individual states will reduce the single area payments in stages, starting with 3% between 2005 and 2008, increasing to 5%, and in this way make available resources which can be targeted to key areas which they see as particularly deserving of support.

There are partial decisions coming from the federal states concerning changes to the current agri-environmental support programs (such as HEKUL and HELP listed in Table 8.5 et seq.). All conceivable modifications have minor significance with respect to the structural changes resulting alone through the single area payments. In actual fact, the agricultural decisions made in 2003 constitute a huge social experiment with unforeseeable consequences for the landscape, and particularly grassland.

If there are no drastic price increases in the beef and mutton markets, then the transition from animal premiums to single area payments must strongly reduce any incentive at all to keep animals for meat production. Because cross compliance requires only the preservation of grassland as such without reference to nature conservational quality, low-cost technical procedures have attracted interest. The ecological effects on landscapes of continuous mulching have received varying judgements from the botanical point of view (Dierschke and Briemle 2002); from the zoological position, there are serious concerns (Oppermann and Gujer 2003).

Payments for Ecological Services

If all market earnings from product sales and production costs are compared, as in the tables above, and are considered to be 'uneconomical' where imbalances arise, one can assess this as a short-sighted judgment as seen from the macroeconomic view. It fails to see that other values are created on the output side which are not compensated by the market because of their qualities of collective benefits. The most important of these values is the preservation and development of the Central European landscapes. If the value of such a landscape (however one may wish to define this) shaped as a result of large-scale grazing is set at €500 ha^{-1} yr^{-1}, then one can say that suckler cow farming with outdoor keeping in winter 'produces' in Table 8.5 the co-product beef (earnings €350) plus landscape (earnings €500) and therefore covers the total costs of €850 (all per hectare per year). It hardly needs mentioning that the exact monetary evaluation of landscape value is very problematic, though this is not a consideration of the work presented here.

If the current support in its complete scope could be seen as a payment for the ecological performance of grazing, there would be no normative-economical objection against this variant in the keeping open of grassland biotopes. In fact, the financial support which is granted consists mainly in income support without any ecological reference. In this way, the support is part of a comprehensive system of payment for ecological performance following a reorganization of the current agricultural income support system. Such a system would be not least politically legitimate while the acceptability of the existing system is crumbling. But there are problems here also: agri-environmental measures which have the objective of maintaining grazing would again connect area use with production and attract this very criticism. All financial subsidies for grazing directly or indirectly support the production of meat, which should be restricted.

As already mentioned, even with the knowledge of first resulting changes in the agricultural structure between 2005 and 2007, the long-term consequences of the agro-political decisions made in 2003 are not foreseeable, particularly for grasslands.

Structural Policy in the Milk Sector

Milk production finds itself experiencing a rapid increase in the individual outputs of animals that would once have been unimaginable: yearly productions of 12 000 kg per cow are no longer exceptional and a general level of 9 000 kg can be reckoned with. With this, the requirements on the energy contents of the green forage (with simultaneous guaranteed minimum structural proportion with regard to ruminants) have increased so much that even the best grass silage with clearly over 6 MJ NEL per kg DM has reached the limits of what can be guaranteed. Because of this, and for cost reasons, there is a danger that through logistical connections and to exploit agglomeration advantages etc. the domestic milk production will shift towards production concentrations near maize cultivations. It cannot be emphasized enough that the future of the whole extensive and intensive grassland use in the low mountain ranges is in danger: the production of beef requires a subsidy which is hard to justify to society and milk production could favor cultivated areas near agglomerations, particularly with a resulting removal of the one-sided support for the 'grandes cultures' (cereal, oil plants, legumes) and with that, lowering opportunity costs in crop cultivation.

A work division between specialty farms breeding young cattle and dairy enterprises would in principle be conceivable, even over these greater distances. This option has already been considered in the early 1990s, in the face of the changed situation for then existing young cattle breeding establishments from the former German Democratic Republic compared with other procedures for cattle farming enterprises in the East German federal states (Heinze 1991). In the East German states, this form of work division could not be maintained as after the reduction in stock levels, many dairy enterprises had their own land and stable capacity for heifer rearing.

More recent publications (Anonymus 2003; Harms 2002; Lührmann 2001, 2004; Weiher and Harms 2002) are again concerned with this subject because of economic considerations. The background to this is the full production capacity of dairy enterprises and the resulting management problems in the subsidiary or secondary production branch of heifer rearing. From this, it appears that through specialization, there are possibilities for breeding as an independent 'service enterprise'. Until now, it has not been possible to prove this hypothetical development with concrete examples. One of the main obstacles to implementation, according to the sources referred to, is the necessary first-class hygiene status with regard to disease in all of the participating enterprises and the necessary confidence of the dairy owner in taking part in this cooperative production.

8.1.8
Recommendations

- It is recommendable that there are structural-political activities which have the aim of preserving even intensive grassland agriculture in the low mountain ranges with dairy cattle, which per se are less attractive with regard to nature conservation. In the case of the Rhoen, the introduction of a regional brand can be considered, in view of the proximity of the Rhein-Main agglomeration.
- The heifer rearing within dairy enterprises can to a large extent be coupled with grazing strategies which conform to nature conservation needs. Here also, the tra-

ditional and often forgotten regional production models between high and low ground farming systems can be linked. Relevant institutions such as cooperatives and pension keeping can be supported. These activities are made easier if milk production remains in the low mountain ranges but even with large separating distances, they are not impossible. The quantitative potential of this option should not be underestimated: among the approximate 4.2 million dairy cows at present in Germany, 863 000 are two-year-old heifers (without beef heifers) and 1.76 million are female cattle between one and two years (without beef cattle) (BMVEL 2004: 125). Even with declining numbers of animals and in view of the obviousness that each heifer does not graze with high nature conservation benefits, it is feasible that several hundred thousand hectares could be grazed. There is no better cost-efficient system of grassland stewardship than with the use of young cattle and the procedure should be given top priority.

- Irrespective of the precarious economics and need for subsidy, beef cattle farming with suckler cows as well as lamb production with sheep herding must keep their place in the landscape, not least because the calculated area potential for young cattle is insufficient, despite the respectability which it enjoys. Effective economic support in this production direction would result from a growing awareness of quality by consumers as well as the necessary incremental transition away from subsidies with purely income-related effects to payments for proven ecological performance, as demanded by numerous experts (DRL 2000; Hampicke and Roth 2000; Roth and Berger 1995; RSU 2002). First of all, the instrument of modulation can be used for such a policy; in the long term, there is no justification for state payments to agriculture which do not support any ecological or other service in return.
- The perspectives for grasslands intended by the agricultural reforms up to 2012 should be carefully analyzed; foreseeable negative developments should be avoided in good time. Worries create the appeal of maintaining grasslands without animals and the possible creation of obstacles against payments for nature conservational grazing with the argument about the re-coupling of landscape stewardship and meat production.

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8.2
Future Scenarios for Livestock Grazing in Peripheral Regions

Michael Rühs · Klemens Karkow · Stefan Kostrzewa · Gunther Rahmlow

8.2.1
Introduction

The development of agriculture, affecting large parts of Germany and Europe, is determined largely by agricultural policy and its financial instruments. In the first years of the 21st century, these are going through a phase of rapid change: the expansion of the EU across Eastern Europe and new reforms affecting the EU common agricultural policy have been decided. But, the practical reaction of the European farmers to the new framework conditions comes with a great deal of insecurity. In this situation, it is difficult to make exact predictions on the effects of the agricultural policy and with that, the future of farming in Europe.

In order to be able to assess future developments, a model of the Hessian Ulstertal (biosphere reserve Rhoen) was used to develop 4 scenarios which were subject to varying agricultural framework conditions. Different developments were explored, ranging from the implementation of the agreed agricultural policy to the extreme situation of a complete abolishment of subsidies (world market liberalization), and including an increased support for ecological service and landscape stewardship. The municipality of Ehrenberg in the Hessian Rhoen was selected as a model region, in which the economic viability of various production branches involving grassland use under the changed conditions are considered, their future development assessed and spatial impacts on the landscape are visualized.

This chapter is connected with the questionnaire given to 21 farm managers which was described in Sect. 7.6. Because of the major changes to the agricultural policy which have arisen in the time since the questionnaire was carried out, some of the scenarios presented here needed to be changed. More details are given in Sect. 7.6 – the results of the questionnaire are still very relevant.

Agricultural scientists have investigated the consequences of the reforms which were decided in 2003 and cover the period until 2013, using extensive and highly complex models in which particularly, the technology of linear programming is used (see Kuhlmann and Möller 2006 and other contributions in No. 5–6 of ‘Agrarwirtschaft’ 2006). Compared to these, the scenario calculations presented here are not only very simple; they also contain many intuitive components. However, experience shows that with careful interpretation, they can also allow important conclusions to be drawn and recommendations to be given.

8.2.2
Basis and Methodology of the Scenario Development

Basis

- Economics of the production branches according to Sect. 8.1
- Assumption of efficient procedures
- Representation of production branches dairy farming, young cattle breeding, suckler cow farming and bullock fattening
- Coverage of full costs for production branches
- Hobby farming is considered

Table 8.13.
Overview of the updated scenarios (see Sect. 7.6)

Scenario		Input
Scenario 1:	Agricultural policy after 2013	Single area payment, €300 per ha/yr
Scenario 2:	Complete market liberalisation	Abolition of all farm subsidies, free world trade
Scenario 3:	Remuneration of ecological services	Single area payments plus goal-oriented remunerations up to €250 per ha/yr
Scenario 4:	Top prices for premium products	No subsidies, 25% of the production receives high price

As part of the arrangement of the scenarios in this chapter, each one was given different inputs. These vary in scenarios 1–3 with respect to the amounts of agricultural subsidy and in the fourth scenario, with respect to the earnings from the product. These inputs are combined with the economic data of the production branches from Sect. 8.1 so that the viability of different branches tied to grassland production can be represented under changed conditions. From the results concerning viability, the scope of the production branches is derived and the resulting estimated land use of the model region is transferred to the maps as background detail.

The inputs for the scenarios are shown in Table 8.13 and are described at the start of every scenario introduction. Scenario 1 contains a continuation of the EU agricultural policy with the reforms agreed in 2003 (more details in Sect. 8.1.7 'subsidies'). The second scenario describes the situation following the complete abolishment of all subsidies under the conditions of world market liberalization.

In the third scenario, there is a reward for ecological services to complement regional single area payments, which replaces subsidies from the previous agri-environmental programs. The fourth scenario represents a variant of the second scenario in which the farmers receive a much higher price for the meat sales from an improved marketing of premium products.

The decision was made not to include a dynamic modeling of the reorganization process and adaptation measures for the various production structures as this would quickly attract criticism of arbitrariness because of the number of relevant detail assumptions and imponderability in individual phases. An exact prediction of the development would also be obstructed by the very individual reactions of farmers to changes in political impositions. Therefore, a comparative-statically approach has been selected which – with small exceptions – is subject in each given future condition to a fictive immediate optimal adaptation. This also means that in scenarios 1 and 3, the transition phase of the 'combi-model' remains disregarded until 2013.

The basis of the economic organization of the scenarios is formed by the grassland-dependent production branches dairy farming, young cattle breeding, suckler cow farming and bullock fattening. It is also assumed that the procedures are carried out with optimal efficiency. For dairy farming, this means a herd size of at least 120 cows per farm. In this region, arable farming plays such a minor role that it will be left out here.

The calculations carried out in Sect. 8.1 are varied in the scenario inputs for the different production branches. Of interest here are above all the contribution margin

(CM) I and II for the production branches. CM I represents the earnings minus the variable costs without green forage and CM II the earnings minus variable costs with green forage costs. If labor and fixed costs are deducted and subsidy money is added, the result is the profit or loss of the enterprise. It has to be underlined that the 'profit/loss' figures given here relate only to the production branch and are not to be understood in the sense of the whole farm's financial status. For the purposes of this work, overhead costs and leasing payments are not taken into account.

In the scenarios, the significant changes are with the amount of subsidy in the so-called *first* and *second axes* of the agricultural support system. The European agricultural budget is divided into two so-called axes. The first axis (about 90% of the current agricultural budget) allows for the payment of direct subsidies as well as weak price support against the world market. The second axis comprises measures for the support of rural areas and the environment. In the fourth scenario, the regional production of premium products and an improved marketing system are central considerations.

As an example of the variations in the economic data, the economic data concerning suckler cow farming are considered in Table 8.14. The first column (year 2002) uses the data from Sect. 8.1, Table 8.5 version with winter outdoor keeping. The stocking level of 0.92 suckler cows per hectare corresponds to a stocking density of 1.2 LSU ha^{-1}. The following columns show the results of the four scenarios and at the foot, CM I and CM II as well as the profit/loss figures. The calculation shows analogously the other

Table 8.14. Plan of the scenario calculations with the example of suckler cow farming (€ ha^{-1} yr^{-1})

	Scenarios				
	2002	1	2	3[c]	4
Variable costs	300	300	300	300	300
Green forage costs	367	367	367	367	367
Labor costs	115	115	115	115	115
Fixed costs	43	43	43	43	43
Total costs	825	825	825	825	825
Product earnings	352	352	352	352	587
Market results	–473	–473	–473	–473	–238
Livestock premium	402				
HEKUL[a]	39	39			
HELP[b]	148	148			
Compensation payment	46				
Single area payment		300		300	
Reward				250	
Sum subsidies/payments	635	487	0	550	0
Contribution margin I (with subsidy)	686	539	52	602	287
Contribution margin II (with subsidy)	319	172	–315	235	–80
Profit/loss (with subsidy)	161	14	–473	195/77	–238

[a] Hessian Cultural Landscape Programme.

[b] Hessian Landscape Stewardship Programme. At the time of the data collection, effective programmes in Hessen.

[c] Two variants, see Table 8.21.

farming variants; the tables in the following sections, however, represent only the results (CM I and CM II and profit/loss).

With full coverage of costs, farm production can proceed economically without time limitations. If this is not possible, then it is a consideration for the enterprise as to whether the contribution margins I and II are still within positive values. If this is the case, the enterprise can continue for a further period. In these circumstances, existing but already written off buildings and machinery are used further.

Using the data on the respective viability and the comparison with the current extent of the procedure, the development of the enterprise in the respective scenarios is calculated. First of all, the development of the more profitable farming procedures for dairy farming and young cattle breeding are considered. The profitability of these determines the number of livestock and therefore the proportion of grassland for the model region. Based on the remaining areas, further land uses are assessed in consideration of the results from suckler cow farming and bullock fattening and the possibilities for hobby farming. Here, we are mainly concerned with statements about the total extent of land use in the region. An estimation of the possible livestock numbers in beef cattle farming and the ratios between suckler cows, beef cattle and perhaps horses from leisure uses is derived from the farmed areas and the stocking densities.

The cattle keeping procedures are described in more detail in Sect. 8.1 and are referred to here briefly with the parameters relevant to this chapter.

- For *dairy farming*, the more efficient variant with 120 cows per farm is selected. A yearly output of 7 500 kg is only possible with energy-rich fodder and it is therefore dependent on suitable land. For all scenarios, we can assume an active milk policy which prevents the movement of dairy farming towards agglomerations. Reference to this and to milk prices is made in Sect. 8.1 (see also Isermeyer 2002). The map depictions for this chapter make clear the concentration of milk production on productive sites close to farm enterprises and with good transport connections.
- The *breeding of young cattle* is above all dependent on dairy farming, which is itself reliant on regular restocking. Through this, there is a high demand and a correspondingly high price for qualitatively high-value breeding heifers. Young cattle breeding can be carried out on much less productive sites which are abundant in the model region.
- For *suckler cow farming*, the procedure variant 2 with outdoor winter keeping was selected. It is represented on the scenario maps together with *bullock fattening* as *beef cattle farming*, as these production branches are very similar in their factor requirements. For beef cattle farming too, the use of low productive sites is a consideration. The comparatively unfavorable situation for beef cattle farming is largely a result of the low prices for slaughter cattle. For reasons of consistency, the price and market earnings from the scenarios in Sect. 8.1 have to be used. As it seems that the price recovery of 25% (see Sect. 8.1.7) evident up to 2006 is maintained, the relation between factor costs and product earnings has shifted towards more positive or at least less negative results for the production branches. But, as is declared in Sect. 8.1.7, this does not lead to a completely different interpretation of the results for the scenarios.

- There remains the further possibility for '*hobby farming*' in the model region. In the course of the decline in agricultural land use, there are numerous areas which can be used by various interest groups. Nature protection groups are taking over land which they consider of value and keeping this open through their own efforts or with animals. Hobby farmers find favorable places to keep their animals. Above all, it is horses and sheep which can be kept on the grasslands of the model region as leisure pursuits. The form of use here is a type of consumption which is not for profit but for the carrying out of an activity which gives pleasure and in which high prices may be paid.

  From an economic viewpoint, a parallel can be drawn between the conditions in private woodlands and hobby uses. That there is also a hobby use taking place in the former, particularly with regard to hunting, is seen from the numerous land purchases by private parties in the states of East Germany, even when forestry uses are very clearly unprofitable. An analogous development for grasslands appears – particularly in attractive landscape regions – quite realistic with a corresponding development of farming, provided that a professionally operated land use which provides for an agricultural infrastructure is associated with this.
- The afforestation of agricultural land as a development alternative is not given further consideration here. There are already calculations on the viability and the costs of afforestation in existence which indicate that this option looks unattractive for individual enterprises without state subsidy (Hampicke 2004). In addition, the keeping open of the land is desired by the society (see Sect. 7.7).

The mapped representation of the land use was carried out with a Geographic Information System (GIS). The basis was a digital land register map together with the real estate information of the area. The individual parcels were complemented with updated land use information. Every farmer has to provide proof about land size, use and stocking levels under the EU Integrated Administration and Control System (in Germany INVEKOS). This data can be used in calculations of the extent and intensity of land use. In some cases, it was necessary to complement INVEKOS data with information from other sources, such as with data from the aerial photograph interpretation (CIR) 'biotopes and types of use', which was available for the whole region.

The various area characteristics were modeled based on the map covering the actual use over the whole of the investigation area. The important parameters of the areas showing a change in land use were found to be mainly soil fertility, distance to villages or farm-steads, slope and exposition. For about 90% of the land, the representation on the map was based on these parameters. In appraisals of individual cases, the various use representations of the other areas were assigned. For the selection of the parts which because of marginal conditions in the scenarios were left fallow, low fertility and steep slopes are the main selection criteria.

The four scenarios are shown successively with the same format: a table with commentary shows the economic viability arising from the given conditions for the enterprises and therefore their preference in each case. From this, the estimated number of livestock in the enterprise can be calculated. In a second table, the required area claims are calculated.

8.2.3
The Scenarios and Their Projection on the Region

Scenario 1:'Agricultural Policy in Germany after 2013'

Framework Conditions

Assumptions
- Full decoupling of direct payments from production
- Skipping of the 'phasing in' of the combi-model until 2013
- Introduction of a parcel-related single area payment of €300 yr^{-1}
- Retention of the agri-environmental payments from second axis of the agricultural policy

Impacts
- Strengthening and therefore small expansion of dairy sector
- Strengthening of young cattle breeding
- Disadvantages in meat production, mainly in bullock fattening, but still positive contribution margins

The elements of the agricultural policy decided in 2003 covering the following ten years and the variants which were agreed on in Germany are briefly described in Sect. 8.1.7 ('subsidies'); the reader is referred to this description. Table 8.15 describes the viability of the production branches under the conditions given in scenario 1. The lowest line gives a comparison of the profit/loss with the agricultural policy up to 2004.

Table 8.15 can be interpreted as follows:

Dairy Farming

Dairy farming in the model region emerges strengthened from the new agricultural policy. A rationalized dairy sector would now earn €626 profit per hectare instead of €413 under the conditions existing in 2002. If one considers the small-scale structure of farming in the municipality of Ehrenberg in the Rhoen, this could mean that the pressure of rationalization is somewhat weakened and many small-scale structures remain in place over a longer period. However, this is dependent on milk prices not dropping significantly under 0.30 cents per liter.

In our scenario, we can assume a small expansion of the gradually rationalized dairy production in the Rhoen based on the better economic results. However, this expansion would be limited by the existence of intensive grassland. The number of dairy

Table 8.15. Viability of different cattle farming procedures in scenario 1 (€ ha^{-1} yr^{-1})

	Dairy cows	Young cattle	Suckler cows	Bullock fattening
Contribution margin I	2 376	1 557	539	257
Contribution margin II	1 802	1 256	172	13
Profit/loss	626	789	14	–293
Profit/loss 2002	413	547	161	169

cows would increase from the previous level of 600 up to 700 animals. Therefore, in this scenario a grazing density of 1.64 LSU ha^{-1} would require an area of 440 ha intensive grassland for dairy farming. Of this area, 200 ha is meadow and 240 ha is pasture.

Young Cattle Breeding

Similarly to dairy farming, the economic results for young cattle breeding have also improved. The good prices were achieved mainly because of the higher regional demand through the coupling with dairy farming (see Sect. 8.1). Because of the higher profitability of this production branch and the demand, we can assume a small increase in livestock numbers up to 500 young cattle, parallel to the numbers for dairy cattle. With a density of 2.3 animals per hectare (about 1.2 LSU ha^{-1}), approximately 150 ha of extensive pasture is needed.

Beef Cattle Farming

As shown in Sect. 8.1, under Agenda 2000 conditions neither suckler cow farming nor bullock fattening can be carried out profitably without considerable subsidies. Direct payments in the form of livestock and slaughter premiums were made available to such an extent by the end of 2004 that suckler cow farming achieved a profit of €161 $ha^{-1}\,yr^{-1}$ and bullock fattening made €167 $ha^{-1}\,yr^{-1}$. With the switching of direct payments per livestock capita to a parcel-related system, there is deterioration in the economic situation in the case of constant livestock numbers. Suckler cow farming finishes with about ‘plus/minus nil’, while bullock fattening becomes pointless in the long run. Of course, the improvement in beef prices already referred to mitigates the effect.

In the long term, the individual farms may be discouraged from new investment in the procedures for beef cattle farming because of its lower attractiveness. A creeping reduction in livestock numbers would be expected. However, any land parcel would probably be taken over by other farms for the safeguarding of the single area payments and through minimum use or absorption into the continuingly stable dairy production.

As is clearly shown in Table 8.14, for the more or less achievable cost neutrality of suckler cow farming in scenario 1 (‘plus/minus nil’), the continuance of the HEKUL and HELP support or a follow-up regulation (in 2006, the ‘HIAP-Programme’, see Hessisches Ministerium für Umwelt, ländlichen Raum und Verbraucherschutz 2007) is a precondition. If this is not the case in the long run, then the prospects for suckler cow farming will deteriorate further.

As is well known, the cross compliance regulations require that grassland areas remain intact and in particular are protected from encroachment by woody vegetation. This can be achieved through technical measures such as the use of mulching. At about €50–€100 $ha^{-1}\,yr^{-1}$ (see Pöllinger and Zentner 2003), the costs of mulching lie well under the deficit level which arises from a suckler cow without subsidy and which was reckoned at €473 $ha^{-1}\,yr^{-1}$ in Sect. 8.1 (see also Table 8.14). There is therefore a strong incentive to completely do without the use of grazing animals and instead to use technical systems to keep grassland open. This problem will occupy nature conservationists for years to come. Almost paradoxically, it is more likely that the extensive, less stony grassland near to the farm would be left over to mulching. However, because of the already mentioned very individual types of reaction shown by the farms, care should be taken with predictions.

Table 8.16. Overview of the land use in the municipality of Ehrenberg in scenario 1 (in ha)

	Dairy cows	Young cattle	Beef cattle and hobby farming	Total area
Livestock (number)	700	500	900	
Grassland	440	225	1 135	1 800
Pasture, intensive	240			240
Pasture, extensive		150	625	775
Meadow, intensive	200			200
Meadow, extensive		75	510	585

Conclusion

In accordance with Table 8.16, it can be expected that about 1 800 ha in the municipality of Ehrenberg will remain farmed land. In dairy farming, there will be a small increase of livestock numbers and an intensification or small expansion of the amount of land farmed. Further areas will be used extensively for young cattle breeding and beef cattle farming. Hobby uses with horses or sheep would expand over the course of time, especially if land becomes available through a decline in beef cattle farming. In this scenario, there is a tendency to keep grassland open at a minimum legal level of stewardship in order to receive the single area payments with as low a cost as possible. Figure 8.1 depicts this tendency in a spatial use structure. As in all of the following representations, there is of course no attempt at a detailed forecast. The intention is to make clear how the results of the research into the scenarios would tend towards a particular spatial arrangement.

Scenario 2: 'Complete Liberalization'

Framework Conditions

Assumptions
- Abolition of all agricultural subsidies
- Meat production at world market conditions and prices
- Remaining regional demand for fresh milk

Impacts
- Clear deterioration in all production branches
- Only dairy farming and young cattle breeding remain profitable
- Suckler cow farming and bullock fattening generate negative contribution margins
- Clear reduction in agriculturally used land in the model region
- Land kept open through hobby uses

The basic assumption from which the further arrangement of this scenario is derived is the complete ending of agricultural subsidy and protective measures within the European domestic market. In the short to medium term, this scenario has a low probability of coming about although its implementation throughout the world is repeatedly demanded by hard-line free trade supporters. In the long term, diminishing

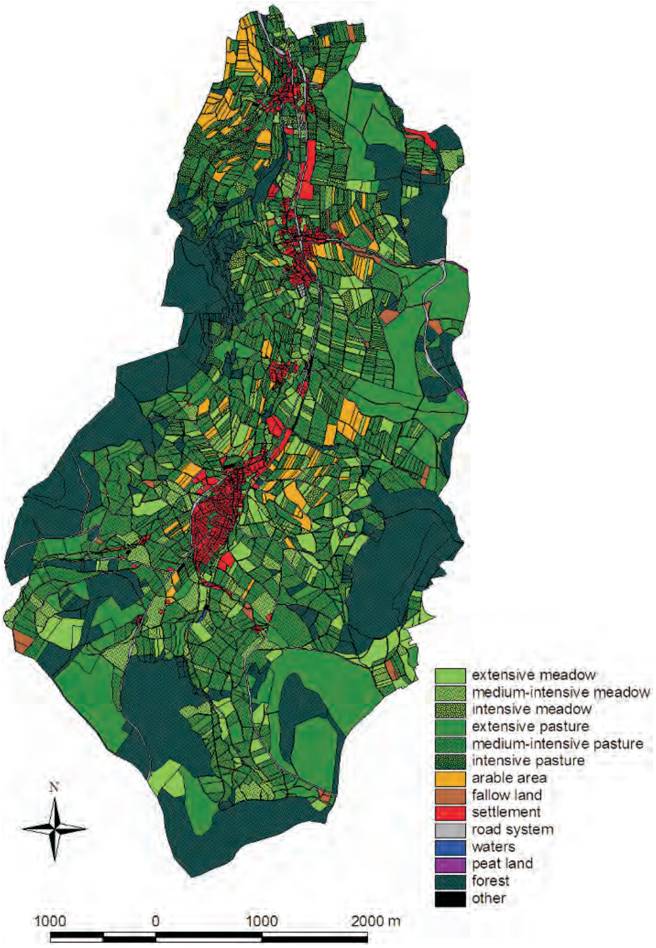

Fig. 8.1.
Overview of land use in in the municipality Ehrenberg in scenario 1 (agricultural policy after 2013)

acceptance of agricultural subsidy within the EU and financial bottle-necks could reduce its utopian status and allow it to become reality at least in parts, possibly after 2013 in the opinion of the pessimists.

In its arrangements, the scenario can be seen as a worst-case situation for EU and German agriculture, because on the one hand, high subsidies fall away and on the other, there is an increase in domestic competition from foreign suppliers. However, this free market can only be considered free to the extent that trade in products appears feasible over long distances. There would be clear restrictions in the area of perishable fresh products such as milk for drinking so one can assume a continuation of demand for regional products.

It is clear that a completely liberalized agricultural market is not compatible with cross compliance. There is neither compulsion nor incentive to farm land.

Table 8.17 shows that, in this scenario, only milk production in well-rationalized farms and heifer breeding can be carried out profitably.

Table 8.17. Profitability of different cattle keeping procedures in scenario 2 (€ ha^{-1} yr^{-1})

	Dairy cow	Young cattle	Suckler cow	Bullock fattening
Contribution margin I	2 076	1 072	52	–113
Contribution margin II	1 502	771	–315	–359
Profit/loss	326	304	–473	–662
Profit/loss 2002	413	547	161	169

Dairy Farming

For the area conditions in the scenario, we can proceed from the optimistic assumption that the total milk production in the region remains approximately unchanged. Because of regional demand, the value creation is sufficient to allow dairy farming to be carried out viably. However, because of the loss of all agricultural subsidies, there is considerable pressure to make increases in efficiency in this production branch. The number of dairy cows in the municipality of Ehrenberg would reduce from the current level of 600 to about 480 cows if the herd average output increases from 6 000 kg to 7 500 kg milk per cow per year. An even greater increase in efficiency is quite possible.

For a number of at most 480 dairy cows in the model region, in line with the given assumptions, about 290 ha of intensive grassland would be needed for a stocking level of 1.64 LSU ha^{-1}, of which 160 ha would be pasture and 130 ha would be meadow. Only the best sites would be used and would therefore be intensified.

Young Cattle Breeding

As already explained in Sect. 8.1, young cattle breeding is highly dependent on an existing dairy production in the region. Without such, there would hardly be any young cattle breeding in the Rhoen area unless a large scale division of work between breeding and milk production could arise. The breeding of young cattle is not dependent on highly-productive grassland sites and can ideally take place in low-yielding regions for landscape stewardship, also in the liberalization scenario. It should be noted that the profits indicated in Table 8.17 assume heifer prices from Sect. 8.1. Should these develop somewhat more weakly, however, the production would still remain in profit.

For the restocking of the 480 dairy cows from the situation given in the scenario, about 120 heifers would be necessary. In addition, about 80 heifers are needed for beef cattle production. With a stocking density of 2.3 breeding heifers per hectare, corresponding to about 1.3 LSU ha^{-1}, 90 ha of grassland would be required in the municipality of Ehrenberg.

Beef Cattle Farming

The profitability of this is so low that it is questionable whether realistic increases in beef prices could take it into positive figures. The cessation of this production in the Rhoen area is therefore expected in the short term for this scenario because even the contribution margins are negative.

Table 8.18. Overview of land use in the municipality Ehrenberg in scenario 2 (in ha)

	Dairy cow	Young cattle	Hobby use	Total area
Livestock (number)	480	200	420	
Grassland	290	90	470	850
Pasture, intensive	160			160
Pasture, extensive		60	260	320
Meadow, intensive	130			130
Meadow, extensive		30	210	240

Hobby Uses and Other Influences

In scenario 2, there are no professional agricultural forces which have an interest in keeping land open outside of dairy production, including young cattle breeding, or which are even interested in using it. If the land is unused, it will be affected by succession, which may be desirable in regions with little woodland but not in the Rhoen, in the opinion of most authorities. To what extent all types of hobby uses can maintain an open landscape, particularly one desirable from a nature conservation point of view, is difficult to foresee in detail; however, a considerable potential could be assumed. As already established, hobby uses derive a big advantage from the existence of a professional agricultural environment. For this reason as well, the continuation of milk production is desirable in the region.

It can also be assumed that the traditional understanding of the landscape by residents and by the tourist industry interests would create a considerable pressure to develop ways of maintaining open land. The success of this is also difficult to predict. However, it is assumed in Table 8.18 that about 470 ha of low-yield grassland is used by hobby interests.

Conclusion

In the liberalization scenario, there is a danger of a large-scale land use, especially on low-yield land. On the other hand, with optimistic assumptions, dairy farming followed by breeding and hobby use could require a total area of 850 ha. Of this, about 290 ha is intensive grassland and 560 is extensive grassland. (For comparison: in 2002, about 1 800 ha were farmed). The possibilities of implementing large-scale grassland pasturing are rated low in this scenario. There would need to be a specific subsidy for such a system as landscape stewardship or as a nature protection program, from state resources. Because similar problems would occur not only in the Rhoen but in all low mountain range regions as well as lowland regions, it could be expected and hoped that there would be sufficient political pressure to either compensate for the undesirable effects on the landscape of radical liberalized agriculture or in fact to put the model from scenario 2 into question. If this does not follow, then one would have to imagine the landscape of the municipality of Ehrenberg something like that in Fig. 8.2.

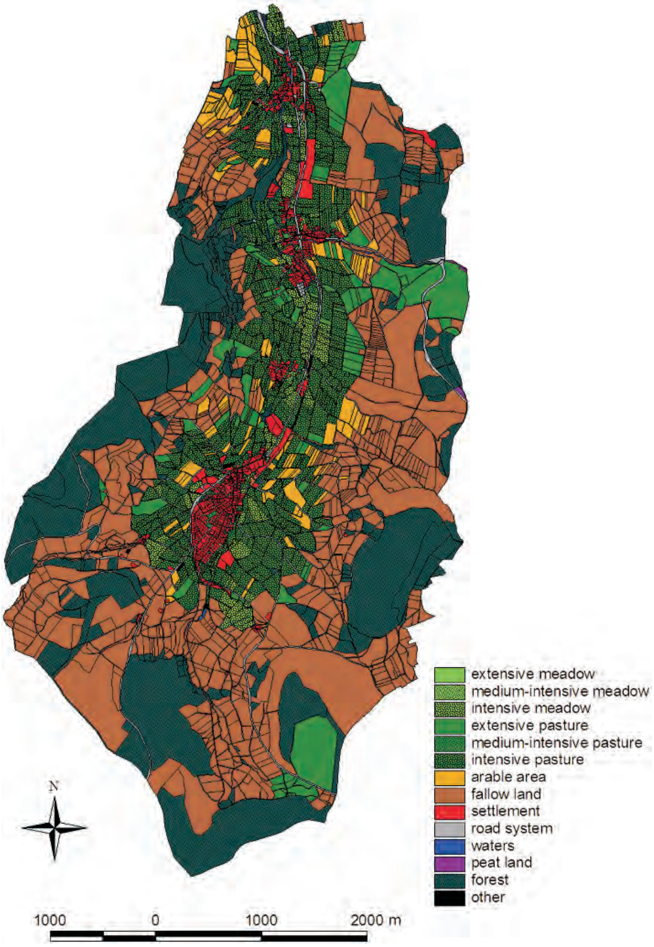

Fig. 8.2.
Overview of land use in the municipality of Ehrenberg in scenario 2 (liberalization)

Scenario 3: 'Remuneration of Ecological Services'

Framework Conditions

Assumptions
- Single area payment of €300 per hectare as in scenario 1
- Goal-oriented remunerations for ecological service
- Maximum yearly €250 per hectare additional premium for the payment
- Abolishment of the current agri-environmental payment of the second axis

Impacts
- Strengthening of dairy farming and young cattle breeding
- Worse results for bullock fattening
- Tendency to extensification in young cattle breeding, suckler cow farming and bullock fattening

This scenario is very acceptable to nature conservation interests and is also enjoying increasing attention within farming circles. It corresponds to scenario 1 but offers an additional reward of up to €250 ha^{-1} yr^{-1} for the achievement of specific ecological services rather than the somewhat unconvincing payments from the agri-environmental program. In contrast to the current action-oriented version, the payments here are based on results. It is left free to the farming enterprise as to how the results are achieved.

Experience up to now with this instrument in Switzerland and in Baden-Württemberg has been very encouraging (Oppermann and Briemle 2002; Oppermann and Gujer 2003); there is a comprehensive documentation of this in BfN (2006). Following a decision of the planning committee PLANAK, the community project 'Improving Agricultural Structure and Coastal Protection' is supporting results-based rewards (Deutscher Bundestag 2006) in which several federal states offer programs (see Kleienburg et al. 2006).

For the grassland in the municipality of Ehrenberg, an evaluation takes into account the following criteria:

- The existence of a minimum number of grassland plants desirable to nature conservation and easily identifiable by the farmers.
- Set levels of maximum allowable bush encroachment. If a level of encroachment is exceeded on the subsidized land, the subsidy is reduced in stages.

The exact arrangement of such a program requires a separate consideration. The economic effects for the farms which enjoy the reward levels are listed in Table 8.19.

Table 8.19 has a different layout to the corresponding ones in the other scenarios as with the exception of milk production, two levels of intensity are observed, one with a stocking density of 1.2 LSU ha^{-1} and one with 0.9.

Dairy Farming

Dairy farming achieves the same results as in scenario 1. However, beef cattle farming deviates to a lesser extent, as the results are clearly better, so we can assume a constant stocking level in dairy farming. We can further assume that the farmers attempt to intensify dairy farming and achieve herd sizes of 120 cows. With 600 cows in the model region, 370 ha of land would be used.

Young Cattle Breeding

For young cattle breeding, which is up to now also well-positioned, it would be further supported with a reward for ecological service. At a level of 450, the number of cattle would correspond roughly with the current use in the Rhoen and require about 230 ha of extensively-used grassland.

Beef Cattle Farming

For both suckler cow farming and bullock fattening, there are interesting decision-making problems for the farms with respect to the choice of an optimal stocking level. It is clear from Table 8.19 that a reduction from 1.2 to 0.9 LSU ha^{-1} would improve the

Table 8.19. Profitability of different cattle farming systems in scenario 3 with varied stocking densities (€ ha^{-1} yr^{-1})

Scenario with rewards			Year 2002
Dairy farming			
Stocking density[a]		1.64	1.64
Basic premium		300	87
Reward		0	0
Contribution margin I		2 376	2 163
Contribution margin II		1 802	1 589
Profit/loss		626	413
Young cattle breeding			
Stocking density[a]	0.9	1.2	1.29
Basic premium	300	300	69
Reward	250	250	174
Contribution margin I	1 296	1 552	1 315
Contribution margin II	1 086	1 270	1 013
Profit/loss	761	834	547
Suckler cows			
Stocking density[a]	0,9	1,2	1,2
Basic premium	300	300	448
Reward	250	250	187
Contribution margin I	588	602	686
Contribution margin II	313	235	319
Profit/loss	195	77	161
Bullock fattening			
Stocking density[a]	0,9	1.2	1.27
Basic premium	300	300	765
Reward	250	250	67
Contribution margin I	470	444	719
Contribution margin II	298	214	474
Profit/loss	84	–73	169

[a] Livestock units (LSU) per ha. A suckler cow with calf corresponds to 1.3 LSU. The variant with 1.2 LSU therefore correspond to a stocking level with 0.92 suckler cows with calf as in Table 8.5 (Sect. 8.1, without stall) and the variant with 0.9 LSU to a level of 0.69 units per ha.

economic success. The reason is clear: in each production branch, each animal brings a loss; the costs are higher than the market performance. The profit arises from the single area payments and the maximum benefit of rewards for ecological service. The lower the stocking level, the lower is the amount further deducted from this payment. However, the farm must not only be aware of cross compliance requirements which have to be fulfilled, it would also need to consider the even stricter requirements which are triggered by reward payments. In general, these would discourage the farmer from making too great a reduction in livestock numbers.

In particular, with a reduction in the stocking density to 0.9 LSU ha^{-1}, suckler cow farming proves to be significantly more successful than in the other scenarios. Even the weakly competitive bullock fattening proves to be profitable although only in extensive systems. The advantage of a stocking density which is as low as possible exists in scenario 1 just as much as in scenario 3. It was also established above that with the feasibility of technical grassland stewardship, there is even an incentive to do without grazing animals completely.

The conflict will be explored in more detail in scenario 3 because the decision-making process, as already mentioned, is complex. In the course of rewarding ecological services, there are possibilities with regard to the large-scale controlling of farm procedures.

To the extent that the subsidized ecological services can also be completely achieved by mulching in some cases, there is little reason in forcing enterprises to keep animals. The financial results of the farms with respect to land stewardship would then be better than is shown in Table 8.19. However, so far as grazing is desirable, it can be made a condition of reward (to the extent that this could be interpreted as a 're-coupling' of payments to production and therefore as a circumvention of the objectives of EU reform cannot be discussed in this work). A combination of various types of procedure including a further reduction in stocking densities with accompanying mulching would be conceivable, as in the left column of Table 8.19, so that even better results than in Table 8.19 can be achieved.

Conclusion

For both scenarios, there is no doubt that the whole of the agricultural land remains preserved (Fig. 8.3). Dairy farming and young cattle breeding come out strengthened. For meat production, there is an incentive to extensification of land use through a reduction in livestock numbers. However, the objective of a high-quality farming of the extensive grassland from the viewpoint of nature conservation can be steadily achieved using the instrument of success-based rewards for ecological services. The farm incomes here perform better than in all the other scenarios. The reward system therefore offers the best conditions for large-scale land use in the model region.

Table 8.20. Overview of land use in the municipality of Ehrenberg in scenario 3 (in ha)

	Dairy cow	Young cattle	Beef cattle	Total area
Livestock (number)	600	450	1 100	
Grassland	370	230	1 200	1 800
Pasture, intensive	200			200
Pasture, extensive		150	700	850
Meadow, intensive	170			170
Meadow, extensive		80	500	580

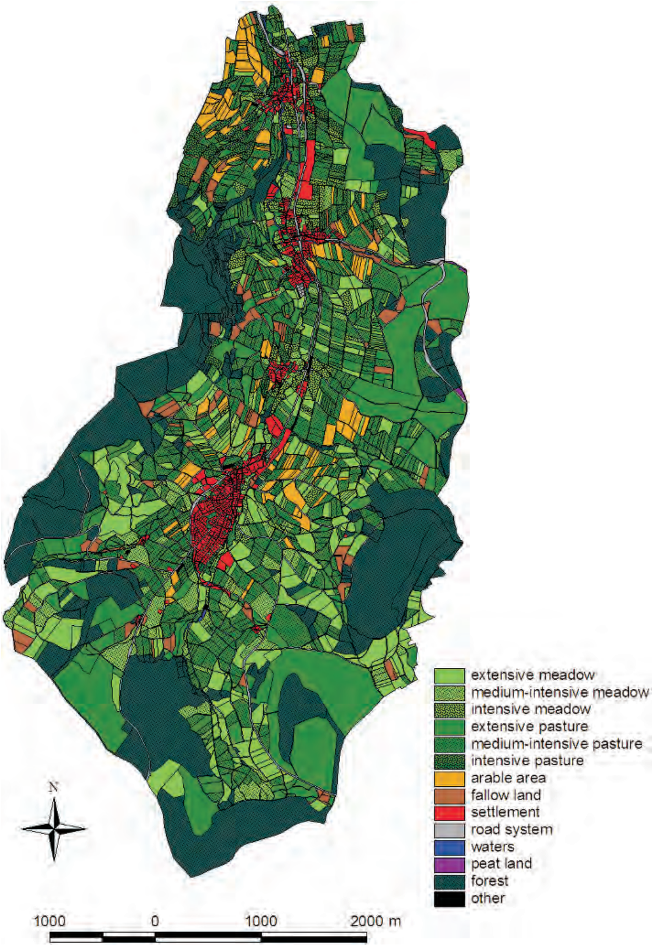

Fig. 8.3.
Overview of the land use in the municipality of Ehrenberg in scenario 3 (remuneration of ecological services)

Scenario 4: 'Production of Premium Products'

Framework Conditions

Assumptions
- Production of high-quality food products with higher sales earnings
- Sale of 75% of production at organic product prices and of 25% at even higher premium prices
- No additional subsidies for agriculture
- No additional expenditure on direct marketing by farmers

Impacts
- Fewer impacts on dairy farming and young cattle breeding
- Only part of the meat production is profitable
- Reduction in livestock numbers
- About 700 ha left fallow

Table 8.21. Earnings from direct sale of premium products in scenario 4 (prices and earnings in Euro)

Outputs	Quantity (kg)	Price per unit	Earnings per animal
Earnings from suckler cow farming			
Heifer sales	44.7	5.00	223
Bull calves	86.6	6.00	520
Proportion old cows	65.5	1.50	98
Sum			841
Earnings from bullock fattening			
Slaughter bullocks	205.3	6.00	1 232

Table 8.22. Profitability of different cattle farming systems in scenario 4 (€ $ha^{-1} yr^{-1}$)

	Dairy cow	Young cattle	Suckler cow[a]	Bullock fattening[a]
Contribution margin I	2 076	1 139	287	390
Contribution margin II	1 502	835	–80	145
Profit/loss	**326**	**370**	**–238**	**–160**
Profit/loss 2002	**413**	**547**	**161**	**169**

[a] 25% premium for direct marketing and 75% for wholesale organic marketing.

The scenario focuses on the production of high-quality foods with the objective of achieving product prices which cover costs, and therefore on a concept which can be practiced in the region and within certain limits, is already practiced. It is, however, subject to the farm not carrying out additional direct marketing which could bring considerable costs, but rather supplying their products to professional outlets. Table 8.21 gives information about the relevant price assumptions for the premium products.

The economic situation of the production branch in scenario 4 in the light of Table 8.22.

Dairy Farming

The situation for milk producers is the same as in scenario 2. Therefore, there is also a tendency here towards intensification with more productive animals and larger stocking levels on each farm.

Young Cattle Breeding

Even if the heifers do not achieve better prices than in scenario 2, production is slightly more successful because it is subject to the heifers separated for fattening also achieving the prices given here.

Beef Cattle Farming

It is assumed that for beef cattle farming, 25% of the current production receives a clearly higher price through the sale of quality meat. The prices for premium meat are in line with market observations while for the remaining 75% of production, producer prices from the organic meat sector for 2002 are assumed (see Goessler 2003).

Table 8.22 shows in a comparison with Table 8.17 that for scenario 2, the favorable marketing of the results for suckler cow farming as well as for bullock fattening are improved by several hundred Euro per hectare per year. However, the price increase is insufficient in both cases to make a profit for the systems. For a long term assurance in both cases, the effects need to be greater – either more than 25% of the product must be within the premium segment or the general price level must be higher. The negative contribution margin II for suckler cow farming means that this branch would quickly withdraw from production. The expected land uses are shown in Table 8.23 and Fig. 8.4.

Conclusion

The price increase model assumed in scenario 4 is simply too weak to replace direct payments per hectare or (as before 2005) per capita of livestock. One reason for this is that milk is not included. Attempts made up to now have with few regional exceptions failed because of a lack of cooperation from the dairies and there is no sign of a change. Rather, a further reduction in milk price under the level given here is feared.

In contrast, the premium segment has been successfully marketed for meat production. However, experience up to now shows that this is only possible for a part of the product volume, which in this work is set optimistically at 25%.

Irrespective of how appropriately the assumptions in scenario 4 have been selected, the calculations should encourage skepticism about concepts which envisage the maintenance of cultural landscapes alone through increasing product prices. Such concepts are also popular in nature conservation circles, where in contrast the remuneration of ecological service does not find universal appeal. In the model region, the premium price model may reduce the degree to which land falls fallow compared to scenario 2 in which all extra-market payments to agriculture are excluded but cannot completely prevent this development.

8.2.4
Summary and Recommendations

It can be ascertained from the maps (Figs. 8.1 and 8.4) and Table 8.24 that in scenarios 1 and 3, a comprehensive agricultural use across the investigated region can be expected. Not unexpectedly, however, are the tendencies to abandon farming, strongly present in scenario 2 and less strongly in scenario 4. According to Table 8.24, the farmed area in scenario 2 reduces by over 50% and in scenario 4 by nearly 40%. It is generally known

Table 8.23. Overview of land use in the municipality of Ehrenberg in scenario 4 (in ha)

	Dairy cows	Young cattle	Beef cattle	Total area
Livestock (number)	480	400	600	
Grassland	290	180	650	1 120
Pasture, intensive	160			160
Pasture, extensive		120	360	480
Meadow, intensive	130			130
Meadow, extensive		60	290	350

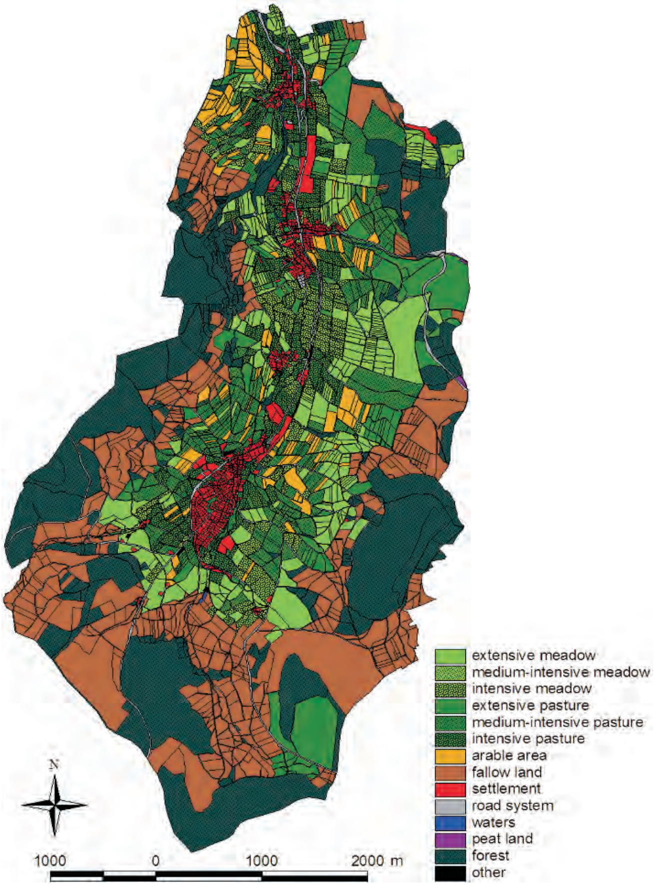

Fig. 8.4.
Overview of land use for the municipality of Ehrenberg in scenario 4 (production of premium products)

that a complete liberalization of agriculture would threaten farming in disadvantaged regions. The limits of the premium price model are also seen clearly. Only hobby interests can maintain open land.

The different proportions of use between intensively and extensively worked grassland which are seen in Table 8.24 reflect mainly the respective competitive forces within milk production. While the absolute profitability in scenario 3 is no less than in scenario 1, lower livestock numbers and stocking densities can be expected in the former because the competitiveness there for meat production is significantly higher. Because of the existing but clearly reduced profitability of milk production in scenarios 2 and 4, a lower level of expansion would be expected.

Again, it must be mentioned that a precondition for all scenarios is an active structural policy in support of milk production in the low mountain ranges, even in the face of total liberalization. How this can come about is not the function of this work. Without it, the 480 dairy cows in scenarios 2 and 4 would be hardly viable. A general displacement of milk production towards arable farming regions would spell the end of the traditional low mountain ranges' agriculture.

Table 8.24. Overview of farmed land in the scenarios (ha)

	Current	Scen. 1	Scen. 2	Scen. 3	Scen. 4
Pasture, intensive	260	240	160	200	160
Pasture, extensive	710	775	320	850	480
Meadow, intensive	330	200	130	170	130
Meadow, extensive	500	585	240	580	350
Total grassland	1800	1800	850	1800	1120

In none of the scenarios is there a danger of an excess of intensification which would threaten the high nature conservational contributions made by extensive grassland use. With regard to the land itself, scenarios 1 and 3 offer good possibilities for large-scale grazing and even scenarios 2 and 4 offer certain possibilities in which stochastic effects would arise. In contrast to the situation in the Thuringian Rhoen (see Sect. 8.3), a greater problem would be the structural characteristics of the farms.

As well as the allocation effects of the scenarios, their distribution effects must be considered. With regard to the financial situation of the farming enterprises, there are clear differences. In scenarios 2 and 4, there is not only the complete loss of income from meat production over the long term (resulting in the abandonment of land, as already mentioned) but also a reduction in income from milk production and young cattle breeding compared to the other scenarios.

In both scenarios 1 and 3, which permit a capacious level of farming, the economic situation of the dairy farmers and young cattle breeders is very favorable. The reasons for this include technical efficiency, subjection to a comparatively acceptable milk price (for which there is no guarantee) and the enjoyment of single area payments in the future. The critical reader who regards milk production in this work as reckoned to be ‘too favorable’ (referring in addition to the general costs not considered here, etc.) may reduce the figures in Table 8.25, but they remain positive.

In scenarios 1 and 3, bullock fattening would phase out or remain at a low level without fixed cost additions utilizing residual capacity. In scenario 1, suckler cow farming hovers a little over ‘plus/minus nil’ and is at great risk of giving way to mechanical land management. Because its ecological effects on the landscape are rewarded, its financial success is considerably greater.

In consideration of all points of view, a complete liberalization of agriculture for low mountain ranges’ characterized by grassland must be rejected. The hope of compensating lost income with higher prices is weakly justified, as was expressed by the farmers in the questionnaire (see Sect. 7.7). Therefore, scenarios 2 and 4 cannot be recommended.

Scenario 1, that is, the regulation provided for 2013, at least guarantees the maintenance of open land through professional agricultural enterprises, even if large areas require mechanical inputs. Scenario 3 brings additional income to the region through rewards for ecological service and therefore ‘costs’ more to society. One can of course assume that such rewards have been earned where they create measurable value. Beyond the fact that it creates greater prosperity for agriculture and provides best protection against the danger of an abandonment of farming, scenario 3 possesses the advantage that through the reward, a degree of control over the type and intensity of land use is possible. The farms

Table 8.25. Overview of the profitability of production branches for all scenarios (€ ha^{-1} yr^{-1})

	2002	1	2	3[a]	4
Dairy cows	413	626	326	626	326
Young cattle breeding	547	789	304	834	370
Suckler cows	161	14	–473(–)	195/77	–238(–)
Bullock fattening	169	–293(+)	–662(–)	–73(+)/84	–160(+)

[a] Variants with 0.9 and 1.2 LSU per ha, see Table 8.19; *(+)* contribution margin II positive, therefore viable short to medium term, *(–)* contribution margin II negative, therefore immediate cessation.

would carry out the work which is requested 'by the bank note'. The survey in 2002 indicated a large extent of acceptance by farm managers for remuneration of ecological service. It would, however, only be successfully taken up in the model if carried out seriously and with planning security, unlike as was often the case in the past.

Therefore, scenario 3 – remuneration of ecological services – is in all regards the preferred choice. Its characteristics are:

- milk production remains in the low mountain ranges
- the heifers from dairy cows are actively brought into grazing extensive grassland, and
- prospects are opened up to combine meat production with rewards for ecological service

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8.3
Economic Analysis of Variants for Large-Scale Grazing in a Farm in the Thuringian Rhoen

Michael Rühs · Jana Lorenz

8.3.1
Introduction

Until now, there has been no research into the impacts on individual farm enterprises following a change in the grazing system to large scale grazing which permits stochastic effects. The following work considers the possibilities of implementing this concept using the example of a large farm in the Thuringian Rhoen, and based on the actual operating situation, calculations on the economic impacts are carried out. Parallel to this on the same farm, a series of ecological investigations as illustrated in this book are also undertaken (see Chap. 6). Because of the size and structure of the enterprise, it is particularly suitable for the investigation of cattle grazing systems on large areas. Large, mainly interconnected areas are farmed with low inputs of farm resources and a secondary activity with suckler cows requires tight pasture management with the main activity of heifer breeding for dairy farming.

The surveyed information and calculations presented here refer exclusively to the part of the enterprise which is concerned with milk heifer breeding and suckler cow farming in a system of seasonal grazing with winter stable keeping.

Two procedural variants on a large-scale pasturing system are considered and compared to the earlier initial situation in which rotational grazing was practiced using paddocks of 8 ha. The first variant is a rotational grazing system with paddocks of about 50 ha and the second is a set stocking system with pasture sizes of about 100 ha. Based on an average stocking density of 1.14 LSU ha^{-1} (livestock units per hectare) pastureland for the earlier system, a lower average density is used in the calculations analogous to the practiced variants in the experimental concepts (see Chap. 6) with reduced stocking densities on large-scale grazing paddocks; in the case of the 50-hectare paddock, by about 20% to 0.9 LSU ha^{-1} and for the 100-hectare set stocking pasture, by about 25% to below 0.85 LSU ha^{-1}.

The enterprise offers two strategies for reaction:

- reduction of milk heifer breeding with retention of suckler cow farming,
- reduction of suckler cow farming with retention of milk heifer breeding.

The operating consequences from both strategies on the enterprise were investigated for both the 50-hectare and the 100-hectare variants and give rise to four cases. Following a comparison of the results between these cases and with the initial system, a recommendation on strategy choice is made.

The reduction in the total number of grazing animals in both strategies can be seen alongside savings potentials for fencing costs and the management of labor through a reduction in rotation frequencies and the abandonment of pasture maintenance. The reduction in stocking levels is based on the assumption that even with complete use of the vegetation growth, this provides less nutritional value for use in later vegetation phases as is shown by observations of animal behavior and canopy structure development (see Chap. 6). So the energetic yield of the land is reduced. This aspect is considered in more detail in the following section.

8.3.2
Methodology

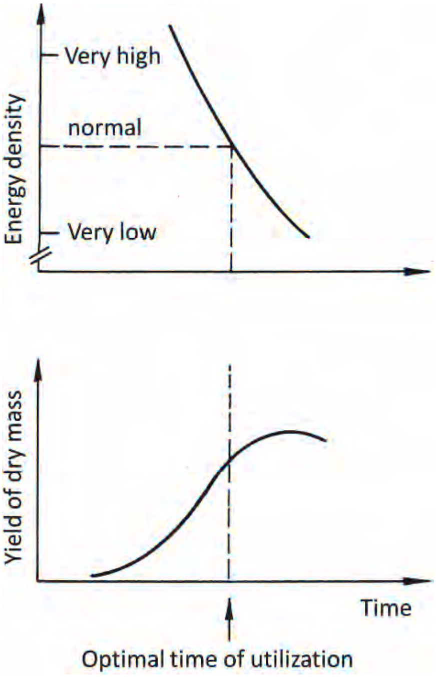
The profitability calculations are organized in line with the procedure cost calculations detailed in Sect. 8.1 and are based on survey and research work carried out by the authors within the cooperating enterprise, as well as on generally available calculation data (e.g., Bezirksregierung Mittelfranken 2000; KTBL 2002; Redelberger 2002; Roth and Berger 1999). Compared to the procedure calculations in Sect. 8.1, changes were carried out in regional adaptations which mainly took into account the longer grazing duration in the continentally characterized eastern part of the Rhoen and also the larger structures of the agricultural enterprises. The collected data and the profitability calculations for the production procedures carried out represent the reference condition (status quo) from which the object variants are derived in further steps.

As well as the numerical calculations, the grassland areas are shown with respect to site, shape and size of the initial condition and also for the object variants. This is done using a GIS mapping system. As well as the grassland areas with the characterization of the land use forms, the infrastructure of the farm relevant to livestock keeping is represented on the maps (see Fig. 8.6).

Based on the actual situation on the farm, which is set up towards an effective exploitation of the natural biotic yield potential, two variants for an expansion of the individually grazed areas are comparatively outlined. In the initial system, there are paddock systems with a total area of on average 50 ha (25–54 ha) which are sub-divided into four to eight paddocks. In both of the object variants, the land use is restructured into a system of large paddocks with 35 to 50 ha in object variant 1 and a system of set stocking pastures of about 100 ha in object variant 2. In the object variants, there is an enlargement of the individual areas for grazing and a reduced number of livestock – because of lower net energy yield – and changes in the labor requirements are assumed because of the lower number of rotations between the paddocks. It is these values which are reflected in the economic calculations of the procedural variants and which can be given as the results per hectare of used pasture. The changed cost and earnings structures of the procedures in the object variants are then compared to the initial situation. By means of this method, it can be assessed as to how far the establishment of large-scale grazing would result in a changed subsidy requirement for individual farms.

The illustration concentrates here completely on the described primary consequences of changes to the system of grazing. No regard is given to medium-term in-house processes of adaptation affecting the whole enterprise (secondary effects) as a reaction to the changes to the management of grazing because of the complexity of the interrelationships between pasture management, green forage production and crop cultivation as well as the possibilities of fodder purchasing. In consideration of individual farm enterprises, it appears that the methods chosen here do not go far enough. For

Fig. 8.5.
Schematic course of dry mass yield and the energy density in vegetation growth of grassland residues (from Jeroch et al. 1993)



the answer to the question of how the *national economic* results of changes to the grazing system can be assessed, however, the procedures selected here offer the correct answers.

The observations on vegetation structure and grazing behavior referred to above, as described in Sect. 6.2, may indicate lower vegetation residues even for large-scale paddock systems, but high-growing (growing to seed) vegetation found during surveying in June and July point to a reduced quality. Basically, for every type of green forage production, a gap opens up between the gross yield (of the standing growth) and the net yield, because technologically produced material and quality losses arise. According to text books on grassland management (Voigtländer and Jacob 1987), grazing residues of from under 10% up to 40% can be assumed with modest grazing, as would occur with suckler cow and young cattle systems that do not require high outputs, depending on the type of grazing (plot, rotational and set stocking grazing). These figures are confirmed by findings in more recent investigations on large-scale grazing systems (Oppermann and Luick 1999). The losses comprise vegetation growths which are rendered unusable because of trampling and contamination by the grazing livestock and which increase with the size of the pasture and the duration of grazing. In fact, the actual conditions are somewhat more complex.

A close analysis of the supply of fresh mass from an area should show it to be lower from large-scale set stocking systems than for comparable rotational systems because of the delayed utilization of the growth and the resulting reduction in the amount of new growth. Because of the higher dry mass content in the available vegetation, this dry mass deficit is partially compensated (Fig. 8.5). The energy content and the digestibility of the vegetation, however, are at such lower levels that the net energy yield of the land declines over the duration of the grazing period (see Sect. 8.3.1). As a result of this, the animals find sufficient fodder mass but not necessarily enough fodder energy to be able to achieve a satisfactory performance.

In the example calculation presented here, a decline of net energy output of between 25% and 30% is reckoned for the change to large-scale systems, oriented to the design of the experiment and the data from the professional literature, as mentioned. It turns out that the underlying energetic outputs of the land agree well with the stocking densities for the experimental design given in Chap. 6. With a cautious assessment of the efficiency of large-scale grazing systems, the results presented here show the upper limits of the expected fodder requirement for the maintenance of this form of land use system.

8.3.3
Farm Organization

The farm in the Thuringian Rhoen which was examined consists of a main farm section in which dairy farming is combined with fodder cultivation and arable farming; the focus here is on milk production. In addition, there is a subsidiary farm section in which suckler cow farming is organized. Both sections operate closely associated in livestock husbandry. With respect to the livestock management, the young beef cattle and heifers are assigned to one work unit along with the dairy heifers and the calves. Within the main farm section, there are 1 000 heifers, young cattle and calves. The subsidiary farm section manages a total of 496.18 ha of land. As part of this, there are about 100 young cattle and carrying heifers, and 218 suckler cows with calf as well as four breeding bulls, giving a total of approximately 535 cattle of the German Simmental breed. In both operations, the heifers are used for restocking purposes and for beef sales. Each year, the subsidiary sells about 170 animals. No animals are purchased. Calving takes place throughout the year and the calves which are sold are about six to seven months old. For the calves under six months old, the loss in the dairy cow section is about 3.5% and in the suckler cow section about 8%. In the dairy cow section, the young cattle or calves remain up to one year in pens. Young cattle older than 12 months and carrying cows and inseminated heifers are put to pasture during the summer months. The calves from the suckler cow section (up to six months) stay with the cows on the pasture.

The cattle pens are arranged in different locations (see Fig. 8.6) For the dairy cows, there are three pens in Kaltensundheim, and likewise for calves, calving and carrying cows. Another stable for about 80 animals is also located in Kaltensundheim. For the winter period, the suckler cows are kept in pens in Oberweid, Mittelsdorf and Kaltenwestheim. The subsidiary operation does not manage its own green forage production but instead cooperates with the production branch arable cultivation and in part with the production branch dairy farming of the main farm section. This delivers straw and winter feed to the suckler pens and the young cattle breeding operation as agreed, and uses the resulting manure on its own production areas.

Cooperation takes place over livestock management in which the suckler cows and young cattle of both farm sections are managed by four people in two teams, each with two colleagues, throughout the year in the subsidiary operation. Each team works about six to eight hours daily with 400 to 500 cattle.

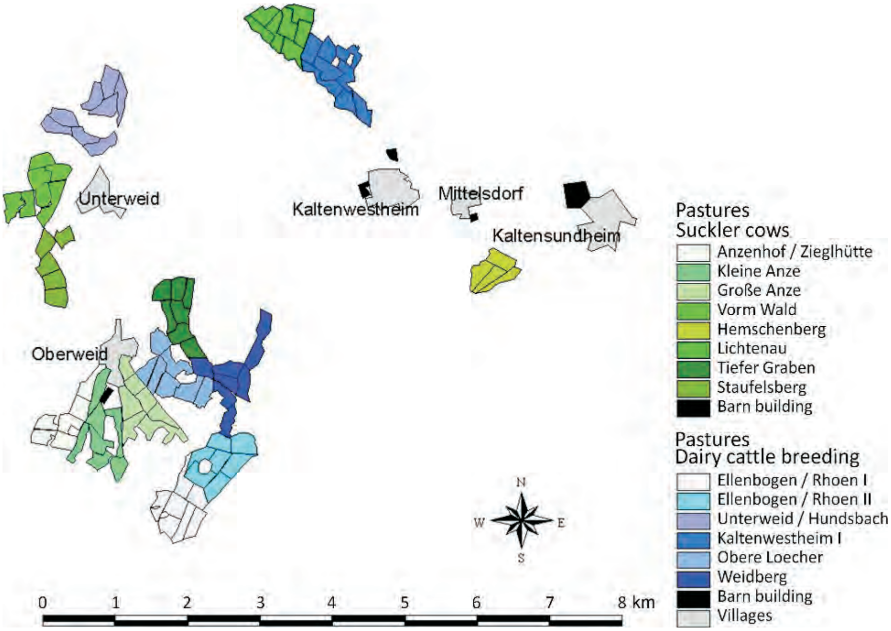


Fig. 8.6. Pasture structure of a large cattle enterprise in the Thuringian Rhoen – starting situation

Within the suckler cow branch and the young cattle and heifer breeding branch of the subsidiary section, grazing takes place on about 320 ha. A further 302 ha are used for grazing by milk heifers from the dairy branch. As a rule, the cattle remain on the pastures from May to October and by favorable weather, from as early as mid-April until as late as the end of November (according to weather conditions, a maximum of 215 days). Calves from the dairy cows in the main section graze for only about 160 days.

8.3.4
Reorganization of the Grazing Operation

Starting Situation

The analysis of farm data is concentrated on the subsidiary section which is concerned with the management of grazing. As no exact survey could be carried out on the yields from the pastures and meadows and it was not possible to systematically undertake an estimate of the pasture output based on weight changes of the grazing animals because of repeated changes in the stocking levels, recourse was made to the farm's estimated values with respect to the dry mass yield. In order to calculate the energy production from green forage, these were calculated with literature values (Briemle et al. 1999; Opitz von Boberfeld 1994) for energy contents of vegetation on similar grassland types. Based on the calculated net energy production (Table 8.26) and requirement calculations for the various animal groups, a fodder energy balance was worked out and an average area requirement per animal was assessed (Table 8.28).

Table 8.26. Overview of total green forage production in the 'pasture operation' of the subsidiary, for the starting situation (based on calculations from farm data and literature values) and for two variants of changed pasture management (authors' own assumptions)

	Rotational grazing current	Rotational grazing 50 ha	Continuous grazing 100 ha
Number of uses	3	1–2	1
Green mass yield, gross (dt/ha)	153	124	124
Dry matter (DM) content (%)	19.5	24	24
Ø DM net yield (dt/ha)	25.36	25.30	25.30
Trampling losses (%)	10	25	30
Usable DM yield (dt/ha)	22.82	18.98	17.71
Energy yield net (MJ ME/ha)	23 459	17 784	16 594
Energy content (MJ ME/kg DM)	10.28	9.37	9.37

Table 8.27. Young cattle numbers in May 2003 (data according to farm report)

Dairy cows		Suckler cows	
Carrying heifers (7 months)	60	Young cattle and carrying heifers	96
Young cattle	291		
Heifers older 12 months	167		
Heifer calves 0–12 months	423		
Bulls older 12 months	10		
Bull calves 0–12 months	42		
Total	1 093		
Of which: in summer on pasture	527	Of which: in summer on pasture	96
all year in stable	466		

The results of these calculations for the starting conditions are separated in the following according to summer and winter green forage. Summaries of the economic calculations for the systems of suckler cow keeping and young cattle breeding follow the balance of the natural values.

Summer Grazing

Based on data provided by the farm, the level of gross green mass yields from the open pasturelands can be assessed as on average 153 decitonnes per hectare (dt ha^{-1}). After deduction of grazing losses, there is an energy yield of on average 23 459 MJ ME ha^{-1} for the pastureland.

Suckler cows and young cattle belonging to the farm cooperative are kept on seasonal pastures. The management of the young cattle takes place in cooperation between the main and subsidiary enterprises. While the young milk heifers from the dairy enterprise are kept throughout the year in pens, the older ones are brought to pasture during summer together with the young cattle from the suckler cow enterprise. Table 8.27 shows the

Table 8.28. Composition of the figures for green forage provision for the different animal groups during the grazing and winter stable period

Summer feed requirements	No. of animals	Energy need/animal (MJ ME) grazing period	Area need total (ha)	Area need (ha/animal)
Suckler cows (215 d) + calves	218	26 356.85	245	1.12
Young cattle (suckler cow, 215 d)	96	15 447.0	64	0.67
Bulls	4	19 887.5	4	0.85
Young cattle (dairy cow, 160 d)	527	13 216.42	297	0.56
Winter feed requirements	**No. of animals**	**Energy need/animal (MJ ME) stable period**	**Area need total (ha)**	**Area need (ha/animal)**
Suckler cows (150 d) + calves	218	18 388.5	71.0	0.33

composition of the young cattle stocks. Depending on location and size, the land is used for rotational or continuous grazing. In 2003, the suckler cows were divided into seven herds, grazing 250 ha of grassland in a rotational system. The rotational pastures consist of in each case, four to eight paddocks of approximately the same size.

In 2003, the young cattle and carrying heifers were divided into eight herds and similarly to the system for suckler cows were grazed on pastures with five to eight paddocks in a rotational system.

The requirement figures with respect to green forage for summer and winter for the individual groups of grazing animals are summarized in Table 8.28. Also shown are the data on energy requirements and the area requirements derived from this. For each animal, about 0.56 to 0.67 ha of pastureland was needed for both young cattle breed for dairy and suckler cows and for young cattle fattening. This requirement increased in very dry years with low pasture yields.

Because the pasturing was carried out within the framework of ecological farming conditions, no mineral fertilizer is used. Even the permissible use of farmyard manure was not practiced. The only return of nutrients to the land was through the cattles' own deposits of feces. As part of the farm's standard procedures, there is a regular mechanical treatment of the pasturelands at the end of the grazing season and the resulting biomass is left on the surface as mulch.

Restructuring

Based on the figures presented above for the requirements of the animal groups and the assessments of the gross energy yield of the pastures, a restructuring of the pasture management was put into practice with the 50 ha and 100 ha variants referred to at the start. The restructuring is oriented to the existing situation and takes into account restrictions on the composition of the land through the existing traffic infrastructure. Existing field ways are not dealt with as obstacles to an interconnection of areas. If necessary, the installation of roll gates in the external fencing could be considered as a long-term solution. In the calculations presented here, however, these are not considered. Figure 8.6 show the pastureland structure at the start situation.

8.3.5
Economic Effects of the Reorganization of Pasture Management

The restructuring led in both variants to a reduction in the necessary fencing as well as a reduction in the frequency of rotations. On the other hand, there were in some cases longer cattle driving routes. In addition, for the large-scale pasturing on the object variants, it can be assumed that the farm management practice of regular post-mowing and occasional seeding can be abandoned. The changes brought about to these factors in the initial situation were determined with the help of a GIS. They are listed in Table 8.29.

In the lower part of Table 8.29, the financial savings potentials for the object variants are shown compared to the starting situation and relating to hectares of pasture land. For the calculation of fencing costs in all variants, a double-wired pasture fence (€0.55 per m length) was assumed for the outer fencing, and for the inner fencing, a single wire electric fence (€0.40 per m length). The labor costs correspond to farm practice at €11 h^{-1}. While the savings potential for labor required to manage the herd and pastures can be immediately exploited, for the fencing costs and machine costs with respect to pasture management, it must be assumed that because of depreciation time, there is a delayed effect of about ten years. In the short term, the savings potential for the objective variants amount to about €50 ha^{-1} and in the long term, savings of over €90 ha^{-1} are possible.

Table 8.29. Parameter values for pasture management in the starting situation and in two object variants

System	Status quo	Variant 1	Variant 2
Herd management			
Work hours total	257.39	43.38	27.34
Work hours per animal	14.53	3.15	2.14
Work hours per hectare	0.41	0.09	0.04
Work costs (€ per ha)	4.55	1.00	0.44
Fencing			
Outer fence (m)	66 259.72	59 405.79	56 066.46
Inner fence (m)	27 002.07	1 605.69	761.77
Fence costs (€ per ha)	21.83	15.35	14.34
Pasture management			
Labor costs (€ per ha)	15.84	–	–
Variable costs(€ per ha)	32.52	–	–
Machine costs (€ per ha)	36.35	2.75	2.58
Pasture management costs (€ per ha)	85.71	2.75	2.58
Savings potential short-term (€ per ha)	–	51.91	52.47
Savings potential long-term (€ per ha)	–	92.99	94.73

The savings potentials listed above contrast with reduced earnings which arise because of the assumed reductions in stocking densities for enlarged individual areas. The reductions in net pasture yield are assumed to be 25% for the 50 ha paddock system and 30% for the 100 ha paddock system, compared to the starting situation, which corresponds to reductions of the stocking level on the pastures of 20% to 25%. For this necessary stock reduction, there are options for both variants allowing either a concentration to the subsidiary suckler cow farming or in the main dairy cow production. A reduction of the suckler cow stock would allow the retention of the young cattle breeding as a service for the main farm section. The stock reduction affects either two-year-old milk heifers or suckler cows and their corresponding calves.

The reduced performance on the income side arises from the extent of the necessary stock reduction and the associated contribution margin II with the reduced numbers. The contribution margin II follows after deduction of the variable costs and the green forage costs from the performances and denotes the contribution of a procedure for the coverage of the fixed and overhead costs of an enterprise. It is used here because it can be assumed that the fixed and overhead costs of the enterprise do not change with the reorganization of the pasture management, with the exception of fencing costs. Table 8.30 shows the economic figures for suckler cow keeping and young cattle breeding of dairy cows, with reference to the enterprise figures determined as regional characteristic values for the starting situation. A change in the cost structure is not assumed except for the already named factors of work expenditure, pasture management and fencing costs. The reduction in the contribution margin counts in the books at full value per unit of livestock less. The calculated reduction relates equally to the labor, management and fencing costs per hectare of farmed pastureland. From the comparison of savings and reduced performances, the change to the average contribution margin per hectare of pasture for the farm in question arises.

The dairy cow enterprise shows a weak plus of about €42 per animal in contribution margin II. The young cattle breeding for use as dairy cows can in comparison achieve clearly better values with about €370 per animal. As can be seen in Table 8.30 this difference in performance shows up clearly in favor of the young cattle breeding because of different demands on the amount of grazed pasture.

If after restructuring of the pasture management and the necessary stock reduction, the enterprise follows a strategy of concentration on independent production with suckler

Table 8.30. Economic figures for production procedures of the grazing operation in the starting situation

	Suckler cow		Young cattle	
	€/animal	€/ha	€/animal	€/ha
Market performance	673.20	445.83	1171.75	2074.00
Variable costs	412.71	273.32	582.58	1031.16
Feed costs	218.23	144.52	218.52	386.78
Contribution margin I	260.49	172.51	589.17	1042.84
Contribution margin II	42.26	27.99	370.65	656.06

Table 8.31. Changes in livestock numbers in the objective variants compared to the starting situation with the concentration on suckler cow keeping (see Table 8.28)

	Status quo		Variant 1		Variant 2	
	Number	ha/ animal	Number	ha/ animal	Number	ha/ animal
Suckler cows (215 d)	218	1.12	218	1.48	218	1.59
Young cattle (suckler cow, 215d)	48	0.67	48	0.98	48	1.05
Carrying heifers (suckler cow, 215 d)	48	0.67	48	0.76	48	0.81
Young cattle (dairy cow, 160 d)	467	0.56	231 (–236)	0.77	203 (–264)	0.82
Carrying heifers (dairy cow, 160 d)	60	0.56	60	0.56	26 (–34)	0.60
Bulls	4	0.85	4	1.16	4	1.20

Table 8.32. Changes in total contribution margins in the example enterprise in the case of a concentration on suckler cow keeping with different variants

	Contribution margin (CM) II (€)		
	Status quo	Variant 1	Variant 2
Dairy cows (218)	9212.68	9212.68	9212.68
Young cattle (dairy cow)	173093.55	85620.15	75241.95
Carrying heifers (dairy cow)	22239.00	22239.00	9636.90
Total contribution margin II	**204545.23**	**117071.83**	**94091.53**
Farmed pastureland (ha)	621.97	623.87	623.97
Av. CM II (€ per ha pasture)	328.86	187.65	150.79
Total difference CM II	–	**–87473.40**	**–110453.70**
Av. CM difference to status quo (€ per ha pasture)	–	**–140.64**	**–177.59**

cows, then the stock level of young cattle reduces by 236 animals in variant 1 and 298 animals in variant 2 (Table 8.31). There is therefore a reduced total contribution margin of €87 473 and €110 453 respectively and a reduced average contribution margin II per hectare of pasture of €140.64 and €177.59 respectively. The results of this strategy are shown summarized in Table 8.32 for both variants in a comparison with the starting situation.

If the results of Table 8.32 are combined with those of Table 8.29, it can be seen that in none of the variants is the saving potential sufficient to compensate the expected reductions in contribution margin. It has already been pointed out that the savings on machine costs for pasture management are only realizable when there is a new investment in equipment.

In variant 1, the concentration on suckler cow keeping means that calculated against the short term saving potential, there is a contribution margin of about €90 ha^{-1}; in variant 2, this increases to €136 ha^{-1} and in the long term there are reductions of €48 and

€85 ha^{-1} respectively. The indicated differences in contributions would need to be paid to the enterprise at least as a yearly reward for the implementation of large-scale grazing on 50 ha and 100 ha paddocks if it were not to be worse off than with the starting situation.

Should the subsidiary farm section decide to focus its activity more strongly on the breeding of young cattle as a service for the dairy enterprise instead of concentrating on its core activity, then in order to compensate for the reduced net yield from the pastures, it would need to forego 96 suckler cows and 44 heifers in variant 1 and 118 suckler cows and 52 heifers in variant 2 (Table 8.33).

Table 8.34 shows that in variant 1 with a reduction in the number of suckler cows, the total contribution margin for the subsidiary section reduces by €4 057; this is €4 987 in variant 2 which must be foregone. For both variants, the restructuring of the pasture system led to very minor changes in the total pasture area. A look at the difference in the average contribution margin per hectare with stock reduction of suckler cows shows a minus of €6.52 per hectare in variant 1 and €8.02 per hectare in variant 2, compared to the starting situation.

Here too, the result must be calculated against the saving potential in Table 8.29. Based on the data presented here which contains only *market earnings* and *costs*, the enterprise would enjoy contribution margin *increases* of about €45 in the short term and €86 in the long term in both variants through a transition to large-scale grazing and the associated acceptance of a minimum yield of green forage and the reduction of the suckler cow stocking level. With respect to costs, financial support would not be required for this transition.

At the time of the investigation, there was an agro-political rule which put into perspective the results determined here from the point of view of the farming enterprise. The production-linked per capita premium for suckler cows – with at the same time, an absence of subsidy for young cattle – largely overcame the competitive disadvantage of suckler cows based on market data. That is the reason why the enterprise did not carry out the reorganization suggested here. It would have lost out on higher subsidy payments.

With the introduction of decoupling since January 01, 2005, this distortion has now lapsed so that now it is not just the wider economic perspective but also the interests

Table 8.33. Changes in livestock numbers in the variants in the case of a concentration on young cattle breeding compared to the starting situation (see Table 8.28)

	Status quo		**Variant 1**		**Variant 2**	
	Number	**ha/ animal**	**Number**	**ha/ animal**	**Number**	**ha/ animal**
Suckler cows (215 d)	218	1.28	122 (–96)	1.54	100 (–118)	1.77
Young cattle (suckler cow, 215 d)	48	0.75	26 (–22)	1.02	22 (–26)	1.17
Carrying heifers (suckler cow, 215 d)	48	0.62	26 (–22)	0.79	22 (–26)	0.91
Young cattle (dairy cow, 160 d)	467	0.64	467	0.79	467	0.91
Carrying heifers (dairy cow, 160 d)	60	0.46	60	0.58	60	0.67
Bulls	4	0.85	2	1.16	2	1.20

Table 8.34. Changes in total contribution margins in the example enterprise in the case of a concentration on young cattle breeding, in different variants

	Contribution margin (CM) II (€)		
	Status quo	**Variant 1**	**Variant 2**
Sucklers (218)	9 212.68	5 155.72	4 226.00
Young cattle (dairy cow)	173 093.55	173 093.55	173 093.55
Carrying heifers (dairy cow)	22 239.00	22 239.00	22 239.00
Total contribution margin II	**204 545.23**	**200 488.27**	**199 558.55**
Farmed pastureland (ha)	621.97	623.87	623.97
Av. CM II (€ per ha pastureland)	328.86	321.36	319.82
Total difference CM II	–	**–4 056.96**	**–4 986.68**
Av. CM difference to status quo (€ per ha pasture)	–	**–6.52**	**–8.02**

of individual farms which represents the selection strategy in reducing suckler cow levels with retention of young cattle stocks. It cannot be ruled out that in the long run, enterprises reorganize to a far greater extent than suggested here and completely give up loss-making suckler cow farming. As it is hard to see that sufficiently high numbers of young cattle from dairy farming could take over the whole grazing, this would not be welcome from the viewpoint of nature conservation.

It is important to realize that even under the agro-political conditions up to January 01, 2005, there was economic leeway for large-scale grazing which would permit stochastic effects so long as the structural conditions of the enterprise were favorable, as was the case in the investigation. The reason is ultimately the high competitiveness of young cattle breeding for milk production, provided that the demand for quality heifers is large enough (see also Sect. 8.1). Even if the transition to large-scale grazing with suckler cows would have had to take place, the necessary subsidy requirement – somewhere between €50 and €100 $ha^{-1}\,yr^{-1}$ – would not have been prohibitively high, compared to subsidies paid for other purposes which hardly appear to be of high-ranking nature conservation value.

The major change to the economic decision-making of farming enterprises brought about since 2005 by decoupling is largely favorable to large-scale grazing in the variants which were investigated here, in that the distorting effects of the livestock premiums per capita is removed, because it forbid the enterprise to give up this branch of production. Of course, there may still be developments over the long terms which are completely unpredictable.

8.3.6
Summary

In a case study, the investigations on the ecological effects of large-scale grazing are complemented with a farm-enterprise analysis. Building on key data from an enterprise forming part of a cooperative undertaking consisting of livestock farming with suckler cows and young cattle breeding for milk production, two concept variants are developed with the objective of reorganizing the whole pasturing system of the subsidiary enterprise into a large-scale grazing system with individual paddocks of 50 ha and 100 ha for permanent pasture.

For these concept variants, changes to the management of labor, investment costs for pasture installations as well as the pasture yield is calculated and compared with savings potentials with reduced outputs for two different operational options.

The transition to large-scale pasturing requires a reduction either in the number of young cattle or of suckler cows because of the resulting reduced production of fodder. The results show that in the first case, there are clear contribution margin reductions per hectare which cannot be compensated for by the concomitant factoral savings such as in fencing. The enterprise could only decide to follow this strategy if there were compensating reward payments, for example, for expected ecological services.

The calculations show that from the economic viewpoint, that is, based alone on factor and product prices, it is significantly more favorable to undertake the adaptation in lievstock numbers through reduced stocking of suckler cows with retention of young cattle breeding. With this reorganization, the factor savings would clearly overcompensate the loss of income, resulting in an increase in contribution margins. The following circumstances make it easier for the enterprise to take up the more advantageous option, as described. Admittedly, long-term developments are possible which go far beyond what is analyzed here. Neither a complete weakening of the interest in grazing with suckler cows nor a loss of regional competitiveness in milk production can be in the interests of nature conservation. The latter would negatively affect the demand for young cattle breeding. As other contributions in this book have shown, there is a need for a purposeful agri-structural strategy in the low mountain range areas.

Apart from these future aspects, the case study shows without doubt that large-scale pasturing which permit stochastic effects can feasibly be implemented where there are favorable structural conditions in place in the farming enterprise.

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8.4
Prospects for the Realization of Large-Scale Pasturing in the Rhoen Biosphere Reserve

Karl-Heinz Kolb

8.4.1
Introduction

The Rhoen is a centuries-old cultural landscape which has been formed by human farming activity and in which grassland makes up the prevailing type of land use. The diverse and structurally rich grassland communities in the Rhoen Biosphere Reserve are home to a wide spectrum of habitat types and possess a biodiversity of national and international importance. These form the character of this 'land of the wide horizons', whose preservation represents the model of the future development of the Rhoen cultural landscape (Planungsbüro Grebe 1995).

The grassland in the Rhoen was formed through grazing with cattle and sheep since the time of the expansion in the High Middle Ages. The high terraces of the Rhoen and the areas of common grazing on their declivities are particularly characteristic and were largely still used for extensive grazing up to the eighteenth century. With the intensification of cattle breeding and the spread of stall keeping in the course of the eighteenth century, the production of winter feed became established on the high ground of the Rhoen in the form of hay making on suitable areas. This hay making still takes place to a large extent along with occasional sheep pasturing. It would, however, have ceased several decades ago if it had not been for nature conservation subsidies made available for its preservation.

For the maintenance and development of an intact cultural landscape, it is necessary that the farming forms which contribute significantly to the preservation of the characteristic landscape image should be integrated into the main activities of the farming enterprises. Only such land uses which are sustainable over the long term without high subsidy levels are able to preserve the overall appearance of the landscape as a cultural landscape and with that, the associated biodiversity.

The basic problem appears here as in many other Mittelgebirge regions with a high proportion of marginal yield locations: despite the clear differences in the structure of land use in the agricultural landscape in the three federal states participating in the biosphere reserve, there is a threat in the next few years of a short to medium term change to the typical and unique Rhoen landscape through a further break up of dairy production brought about by a withdrawal from grassland use and also an intensification of use, as well as through increasing numbers of farm abandonments. The introduction and establishment of various forms of large-scale pasturing could represent an economic, and from the point of view of nature conservation, sensible alternative to the hitherto practiced, mainly expensive, and with the current level, barely financeable stewardship measures for maintaining open grassland, providing that the new EU agricultural reform sets favorable conditions.

In the last few years, two extensive projects have been carried out in the Rhoen Biosphere Reserve concerning pasturing in this area: the BMBF initiated research project

"Large-scale livestock farming as a contribution to sustainable development in 'peripheral areas'", which was completed recently and which is described in the previous chapters, and the project 'Landscape preservation with livestock in a socio-economic context – using the example of selected villages in the Rhoen Biosphere Reserve' (Rahmann and Tawfik 2001). This last project is based on the EU-share-cost-project EQULFA 'Husbandry Systems and Sustainable Social/Environmental Quality in Less Favored Areas' and had a duration of five years (03/1996–02/2000). The project objectives were to assess the agri-structural and associated ecological effects as well as social considerations arising from agri-environmental measures (culture landscape program based on 2078/92 which has been the relevant reformed agricultural policy since 1992) with the example of the Rhoen. On this basis, possible future developments are to be derived and adaptation requirements represented (policy decision framework). The study concentrated on extensive pasturing (sheep and cattle).

The results and the prospects indicated for the Rhoen from these projects require a practical implementation. The major changes affecting the future of agriculture and the urgently needed creation of new, sustainable perspectives for farmers in the Rhoen offer favorable conditions and a framework for the achievement of this. The current level of acceptance by the local population and the authorities for such a practically based pasturing project is high.

8.4.2

Current Position of Agriculture in the Federal States Participating in the Rhoen Biosphere Reserve and the Resulting Prospects for the Establishment of Large-Scale Extensive Grazing Systems

Overview of the Agricultural Situation in the Rhoen

With a total proportion of 54% of the land in agricultural use, the Rhoen is even now still significantly characterized by farming (Grebe and Bauernschmitt 1995). The intensification which has taken place since the end of the Second World War across German agriculture and the associated technical innovation (mechanization, plant protection etc.) has affected the Rhoen cultural landscape less so than other regions in Germany (Bach et al. 1994; Fuchs 1973). This applies particularly to the Hessian and Bavarian Rhoen with their small-structured agriculture. In the Thuringian part on the other hand, intensification of farming was forced at considerable pace until 1989 within the framework of the East German planned economy system and this is reflected in the field sizes.

For the maintenance of an open landscape and the preservation of valuable grassland vegetation types (mountain pasture, neglected grassland, wet meadows) livestock farming was and remains a central precondition in the region. Only with a corresponding stocking level can the resulting cut vegetation be integrated properly into the main land use and there is no pasture care oriented purely towards nature conservation, but rather a careful use with a sensible utilization of the vegetation (Grebe and Bauernschmitt 1995).

Because of the high proportion of grassland, cattle farming has a high level of importance over the whole of the Rhoen Biosphere Reserve. Additionally, sheep farming plays an important role in landscape stewardship and nature conservation, particularly in the Bavarian and Thuringian parts of the Rhoen.

The different natural conditions and in particular, the agri-political and economic framework conditions led to the development of various farm structures in the three federal states of the Rhoen. In the Thuringian part of the Rhoen Biosphere Reserve, agricultural production cooperatives farmed until reunification in 1989 with farm sizes of 2 000–3 000 ha, which largely became agri-cooperatives of similar sizes after reunification. In the Bavarian and Hessian part of the Rhoen Biosphere Reserve, there is a predominance of small to middle sized family enterprises mainly well under 50 ha and which are largely operated as secondary occupations. In spite of the comparative similarities between Bavaria and Hesse, there are clear differences with regard to farm sizes, which are even smaller in the Bavarian area.

Bavaria

In the Bavarian Rhoen, the agricultural structure is characterized by a high number of increasingly small farms run as secondary occupations traditionally set up for self supply. The small farm sizes are largely determined by the ownership situation; in Franconia, the system of property inheritance operating for hundreds of years has resulted in extremely small and fragmented sites. A typical example is shown by the community of Oberelsbach in which until today, only a small part of the district meadowland has been subject to land consolidation (Fig. 8.7). This extreme fragmentation of estates represents a central problem for the establishment of large-scale pasturing in the Bavarian Rhoen. Because of the very small parcels of land and the high numbers of different owners, it is very difficult to aggregate land areas which would be suitable for large-scale pasturing. A possible solution to this could be in bringing together several farmers to form pasture communities or similar communal farm organizations.

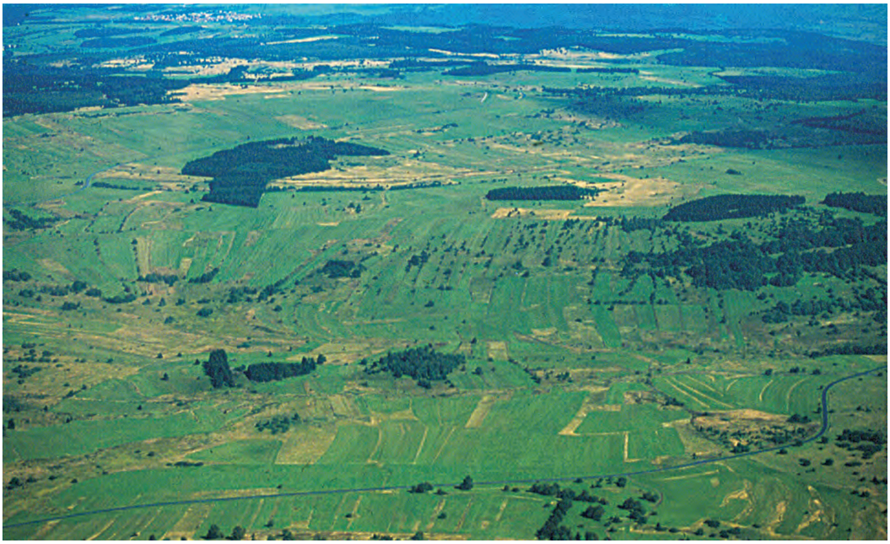

Fig. 8.7. View of the cultural landscape of the 'Lange Rhoen' looking north-east. Notice the small size and close mesh of plots! (Photo: K.-H. Kolb)

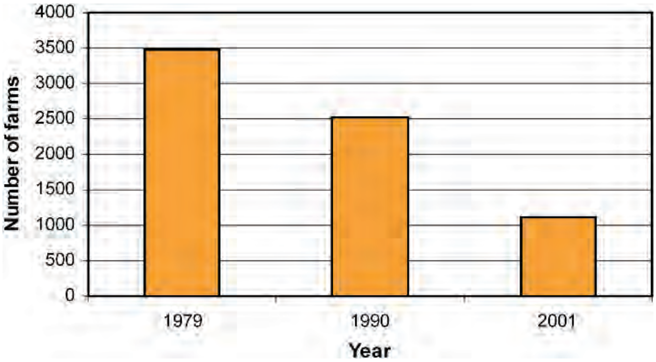

Fig. 8.8.
Development of farms in the Bavarian Rhoen from 1979–2001 (data source: Department of Agriculture, Bad Neustadt/Bad Kissingen)

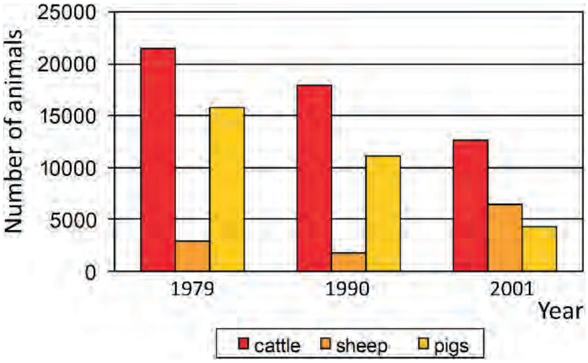

Fig. 8.9.
Development of livestock in the Bavarian Rhoen from 1979–2001 (data source: Department of Agriculture, Bad Neustadt/Bad Kissingen)

In Bavaria in the last few decades, there has been a rapidly increasing farm abandonment because of the advancing ages of farmers, the lack of a farm successor and the uneconomic farm sizes, affecting mainly the small farms up to 10 ha operating as secondary activities (Busch 1998) (Fig. 8.8). This large decrease in the total number of farms is not compensated for by any sort of increase in the larger enterprises. The areas becoming free are only in part taken up by the larger enterprises and so in the future, there could be problems arising in land management.

With the decrease in farm numbers, livestock levels in the region have decreased greatly, above all with respect to cattle farming. Although the number of animals has decreased less than the number of farms because of enlargement of the remaining farms, there has been however a considerable reduction in stock levels, particularly of dairy cows. Since the middle of the 1980s, there has been a counter trend for sheep farming, probably as a result of the animal subsidy introduced at this time (Fig. 8.9). With this given situation, the establishment of large-scale pasturing in the Bavarian part of the Rhoen Biosphere Reserve can be classed as difficult.

A problem area in which the establishment of large-scale, extensive pasturing could offer future solutions is the currently high costs of landscape stewardship. The management of the grassland which is particularly valuable to nature conservation in the high areas of the Bavarian Rhoen, particularly in the conservation area called 'Lange Rhoen', includes stewardship measures which are financed by the Bavarian nature conservation agreements program. In total, there are about 1 400 ha of grassland in the Lange Rhoen which are subject to subsidy, of which about 1 000 ha are mowed and about 400 grazed. Whether sufficient finances will be available in the future to maintain the management of this area is currently not clear. However, for the preservation of this typical semi-open landscape type, the 'land of the wide horizons', which justifies the attractiveness of this landscape to nature protection and tourism, the management of the grassland is indispensable.

Because the level of subsidy within the nature conservation agreements program for grazed land is only about a third of the level available for mowed land, it may be that in the future, from the viewpoint of nature conservation and economics, a large-scale pasturing on suitable land would be the choice method to keep the grassland areas of the high Rhoen open. Also with respect to the problem in mowing management systems of woodland succession on land which cannot be mowed or can only be mowed in certain circumstances (dry years) leading to progressive bush encroachment through irregular use, the land would favorably be managed through grazing.

In Bavaria, starting points for the introduction of large-scale pasturing, particularly with cattle and multi-species grazing, could be the large areas of former common grazing lands which are currently being grazed over much of the area by sheep, although cattle were also grazed in the past. Other areas could become available through land purchases under the national support project 'Hohe Rhoen/Lange Rhoen' (with a total area of about 600 ha) from which a connected area of about 100 ha in the 'Lange Rhoen' nature conservation area which is under the ownership of the district administration of Rhoen-Grabfeld is potentially suitable. The existing suckler cow farmers among the agricultural enterprises represent important starting points for the establishment of large-scale pasturing in the Bavarian Rhoen. They should therefore be included at the start of relevant considerations.

Hesse

In the Hessian Rhoen, the agri-structural situation compared to Bavaria is on average somewhat more favorable. Because of the system of inheritance law practiced here in which the property is inherited intact, the farms here enjoy a better land configuration. The ratio of main occupation to secondary occupation is likewise different to that in Bavaria and 25% of the farms work 50% of the land. In general, the farm units are larger in Hesse and there has been a clear increase in larger farms in the last few years. One exception here is with the farms in the high-lying districts (e.g., Ehrenberg-Seiferts, Hilders-Simmershausen), which are exclusively operated as secondary occupations. Figure 8.10 shows the development of farms in the communities in the Hessian part of the Biosphere Reserve since 1979. In the Hessian Rhoen, too, the number of farms has clearly decreased in the last few decades, although not as drastically as in Bavaria. But here too, a dramatic structural change is forecast for farms in the future because of the family structures.

According to Grebe and Bauernschmitt (1995), dairy cow farming in the Hessian part of the Rhoen Biosphere Reserve and the associated young cattle breeding form the most important production branches, which explains the high number of grassland enterprises. Figure 8.11 shows the development in the last decade. In contrast to

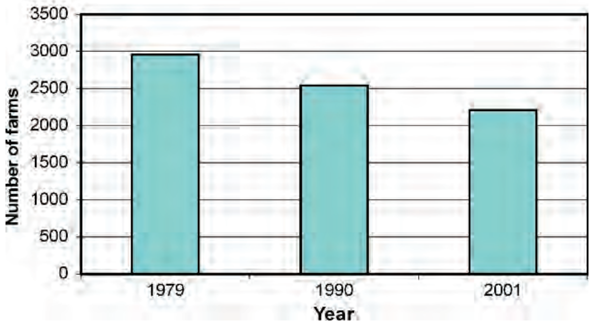

Fig. 8.10.
Development of farms in the Hessian Rhoen from 1979–2001 (data source: Department for Rural Areas, Fulda)

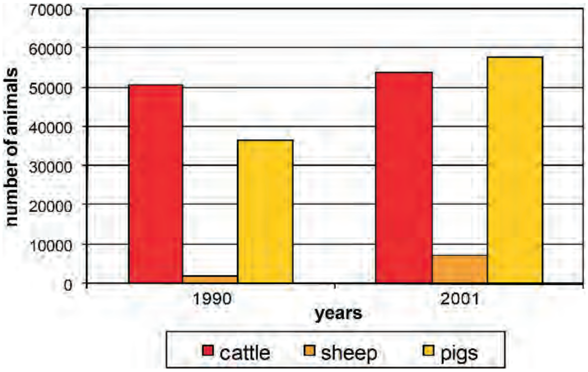

Fig. 8.11.
Development of livestock in the Hessian Rhoen from 1990–2001 (data source: Department for Rural Areas, Fulda)

the situation in the Bavarian part of the Rhoen, summer grazing with cattle herds is widely distributed.

The conditions for the establishment of large-scale grazing are on the whole more positive in Hesse than in Bavaria. In contrast to the situation in Bavaria, the stock levels have even increased in the last ten years, probably through enlargement of several enterprises. Also the high total number of grassland enterprises and the much higher number of farms operating as a main occupation than in Bavaria can be considered as favorable preconditions. Because of the system of inheritance, a land aggregation that would give suitably large grazing units is much easier to achieve than in Bavaria. The better land organization of the small farms and the presence of large enterprises operating as main occupations mean that the problem which arises in Bavaria of getting suitable areas of land only through merger agreements between several farmers is not so striking in the Hessian Rhoen.

In Hesse too, the financial support for nature conservation is in short supply and will remain so in the future. In spite of the fact that the grassland areas in the Hessian high Rhoen, which are valuable for nature conservation and are listed as large-area nature conservation and landscape protection areas as in Bavaria and Thuringia, are widely grazed and only mowed to a small extent, the presence of large-scale grazing represents here too a sensible alternative to the current land use for the maintenance of an open landscape from an economic and nature conservation viewpoint.

Starting points for the establishment of large-scale grazing in Hesse are offered by the large communal pastures, above all in Ulstertal, which are currently stocked mainly with pensioned cattle from outlying areas of the Rhoen and are used as parcel grazing. It would be possible here in the relatively short term to initiate a system of large-scale pasturing through a change in the grazing regime and a corresponding use of the whole herding area.

Further suitable areas are to be found at the large spruce tree clearance sites near the 'Rotes Moor' conservation area, where a spruce plantation was cleared as part of the program of habitat enlargement for the black grouse. Parts of this area are currently grazed by cattle so that here too, with only a small effort to increase the pasture size and adapt the stock levels, a large-scale extensive pasturing system could be established.

Thuringia

In the Thuringian part of the Rhoen Biosphere Reserve, the agricultural situation is characterized by the restructuring of the production cooperatives which were in existence before reunification and the associated clarification of the ownership situation. The agricultural production cooperatives which operated dairy and suckler cow farming on a large scale (several hundred cattle units) were for the most part converted to farm cooperatives which are currently managed as private limited companies. The number of restored enterprises working on returned private land is very small and is mainly limited to the more favored locations (e.g., Geisaer Land, Ulsteraue). The size of the family farm enterprises resulting from restored land lies between 30 ha to 40 ha. On the high terraces, there are still some small grassland enterprises which were not collectivized by the East German regime. Otherwise, there is a general absence of small-farm structures in the Thuringian Rhoen. At present, 13 large enterprises with an average of 2500 ha manage about 80% of the agricultural land. Some of these enterprises are however, only partially within the Biosphere Reserve.

For the large enterprises too in the Thuringian part of the Rhoen, the most important production branch is dairy farming (e.g., Agrar-Höfe Kaltensundheim). In addition, suckler cow farming has a certain role (e.g., Agrargenossenschaft Frankenheim). After reunification, there was a drastic reduction in animal levels in the former production cooperatives of the Thuringian Rhoen. The numbers of cattle kept in the district of Schmalkalden-Meinigen, which had 37000 head in 1989, declined to 27000 by May 1991 (down 27%). An important difference in livestock farming compared to Bavaria and Hesse is that the animals are kept mainly in much larger stock numbers. Additionally, sheep farming currently has some significance. Sheep farming played a role in about 90% of the farms in 1990 although from the large flocks that existed before reunification, there are currently less than half the numbers remaining.

Because of the completely different agricultural structure in the Thuringian Rhoen, the conditions for the introduction of large-scale pasturing are quite different than in Bavaria and Hesse. The very large sizes of the farm cooperatives should make it quite feasible to find pastures over 100 ha and over for large-scale grazing. In the research project described in this book, the 'trial fields' were up to 50 ha (see previous chapter), which shows the potential of the cooperatives to provide connected areas of suitable sizes.

In the Thuringian part of the Biosphere Reserve, it appears that the decisive factor for the establishment of large scale pasturing is the work of persuasion that has to be done in the farm cooperatives. If these can be convinced of the meaningfulness of such a grazing system, above all from an economic point of view, then the introduction here should cause far less problem than in Bavaria and Hesse.

8.4.3
Stages in the Initialization of Large-Scale Pasturing in the Rhoen Biosphere Reserve

Large-Scale, Extensive Pasturing As an Opportunity to Preserve Agriculture and Therefore the Cultural Landscape in the Rhoen

In the last few years, there have been various initiatives by agricultural officials, the Biosphere Reserve management and farmers' associations to improve the desolate situation of grassland management in the Rhoen, particularly with regard to the utilization of vegetation growth, which have generally met with very limited success. Because of the steadily decreasing number of farms and the associated decrease in livestock levels, above all in the Bavarian part of the Biosphere Reserve, the integration of grassland growth into the main land use is and will remain very difficult. The utilization of growth through the classical 'course feeders' (cattle, sheep, horses and goats) is indispensable in the long term in maintaining the typical cultural landscape of the Rhoen for the future. Measures currently practiced such as mowing operations are not financeable in the long term and also not technically sensible.

Out of the urgent necessity and the realization of the need to find new perspectives for agriculture in the Rhoen, particularly for grassland use, agricultural officials, Biosphere Reserve management, farmers' associations and nature conservation associations have been working together since 2003. Largely motivated by a species protection project of the foundation for threatened species of the Frankfurt Zoological Society (ZGF), running since 1996, they have operated a concentrated search for ways of giving a new perspective to agriculture in the Biosphere Reserve and in this way, to preserve the landscape image of the Rhoen made valuable through the characteristic grassland. From the detailed results and extensive recommendations of the above-mentioned research projects on large-scale pasturing, interesting and practicable solutions for the future with respect to both nature conservation and the economic considerations have crystallized. The establishment of large-scale grazing systems represents a realistic opportunity for the preservation of agriculture and with that, the unique cultural landscape of the Rhoen. Because of this, the various authorities, associations and land users involved in brainstorming, open discussions on the need and necessity of protecting grassland in the Biosphere Reserve held on November 19, 2003 decided to initiate a practical implementation project on large-scale grazing. Following this, there were a number of events with the purpose of defining the idea more precisely for the Rhoen and particularly to present it to the farmers whose support is needed.

Objectives to Be Followed for the Establishment of Large-Scale Pasturing in the Rhoen Biosphere Reserve

The main objective of the currently operating implementation project is to test various representative forms of grazing on large areas and at the same time to analyze the socio-economic and nature conservational effects so that framework information for the realization of future grazing models can be derived, also for other regions, with respect to:

- Summer set stocking pastures with domestic cattle breeds;
- All year set stocking with domestic cattle breeds;
- Heck cattle grazing all year (Heck cattle are a re-breed of the wild Aurochs);
- Sheep and goat herded keeping;
- Herded cattle keeping (possibly);
- Mixed grazing with various domestic breeds (cattle/horses or sheep/goats).

Out of the previous research projects, which did not contain any practical implementation results, there was among other things a decision-making grid for the selection of suitable areas for the establishment of large-scale livestock grazing, as well as descriptions of nature conservational and socio-economic effects. These findings will serve in the selection of the most suitable land over the area, and with that, in including the best possible chances of success over the medium and long term. The implementation project is based on case examples with relevant framework conditions (land suitability, cooperative farmers etc.) which can serve as growth points (best practice examples) for the large-scale and further diversification of implementation.

In this sub-project, the above mentioned grazing models are carried out in an exemplary way with an accompanying investigation of the effects. There is a focus on the socio-economic indicators with the objective of achieving economic sustainability, also with respect to the changing subsidies in the framework of the EU agricultural policy. A criteria grid will be developed for different scenarios to help with an assessment of which grazing models and farm structures would be able to bring nature conservation and economics under one roof (a win-win situation).

The development and support of marketing procedures and strategies, a sound advisory service for farmers, a comprehensive public relations work, the subsidization of investments in new projects to support the readiness of farmers to cooperate – all these form the indispensable conditions for the creation of the organizational and economic basis of these new grazing models.

Basis for a Practical Grazing Project in the Rhoen Biosphere Reserve

In numerous pre-meetings, potential practice examples were examined and tested to find out if they offered a suitable project basis which could be achievable in the short to medium term. Particular attention was given to the question of which areas, which land and which partners could be suitable for the implementation. The following points describe the current position in the three federal states involved in the Biosphere Reserve:

Bavaria

- combination of large-scale pastures with the preservation of the Yellow Franconian Cattle
  - through aggregation of ± interconnected pastures of about 20 ha in sloping locations in Ginolfs-Weisbach on a communal pasture used in the past for sheep grazing (perhaps with the inclusion of woodland edges) – the organic farm operating in this area as a secondary occupation has begun to change over to Yellow Franconian Cattle
  - through further consolidation of suitable grassland on the slopes at Weisbach – this conventional farm operating as a secondary occupation has owned a Franconian breeding bull for two years
  - through aggregation of ± interconnected pastures in the pass between Arnsberg and Schachen in the district of Oberweißenbrunn – an amalgamation of the operating farmers is possible and one had already changed over to Yellow Franconian Cattle some years ago
- horse grazing and mixed grazing with horses/cattle
  - enlargement of the existing pastures of three small farms operating as secondary occupations in the area Unterweißenbrunn/Bischofsheim which operate horse grazing and mixed grazing with horses and cattle.
- meadow grazing in cooperation with the project 'Sinn-Allianz'
  - in Sinntal: enlargement of an existing extensively used cattle pasture and the establishment of a project on 'nature development through large-scale extensive pasturing' (the effects of beavers as a special case)
  - in Krechenbachtal: amalgamation of the currently separated pasturelands with different owners to form a common pasture allowing large-scale grazing of the valley plains and slopes of the Krechenbachtal (>20 ha)
- expansion of Heck cattle keeping near the 'Schwarze Moore'
  - extension of the pastureland (currently about 25 ha) to larger areas, possibly into the Hessian or Thuringian area (target at least 60 ha)

Hesse

- Opening of the pasture fences to create a large-scale pastureland on the former Ehrenberg common grazings
  - mainly on the Melperts grazing but also on the Wüstensachsen and Seiferts grazings; other possibilities include the Pferdskopf – grazing is currently operated with pensioned cattle on parcels of land
- inclusion into the project of the former pasturelands from the incorporation of the Rhoen Biosphere cattle at Mathesberg (about 72 ha) and in the conservation area 'Rotes Moor' and its edge land
- intake of two further areas totaling 110 ha (100 ha +10 ha) as a large-scale pasture for the incorporation of the Rhoen Biosphere cattle – strategy for 2006

Thuringia

- Continuation of the existing experimental situation from the research project or the setting up of a similar situation in another large enterprise

The following general project objectives should be pursued with the implementation goals:

1. preservation of an area-wide land management in areas threatened by land abandonment through the implanting of a system of large-scale, extensive pasturing
2. the creation of practical model solutions which will deliver transferable framework data for the implementation of future grazing models to be initiated in other nature areas
3. the setting up of a marketing system for premium animal products produced from large-scale extensive grazing using the model of the Rhoen sheep-marketing system
4. use of the project within the framework of training for sustainability in accordance with the Seville Strategy (1996), under which UNESCO Biosphere reserves should become model regions for sustainable development

From the described sub-objectives, the following sub-projects are derived which should be processed in the scope of the project planning, implementation and evaluation:

- Sub-project 1: Advice
- Sub-project 2: Practical implementation of individual projects
- Sub-project 3: Nature conservation monitoring
- Sub-project 4: Socio-economic monitoring
- Sub-project 5: Marketing
- Sub-project 6: Training for sustainability
- Sub-project 7: Creation of transferable model solutions

In the current implementation objectives, the breed called Yellow Franconian Cattle will be particularly supported. A significant consideration for the re-establishment of this old breed in the Rhoen is the fact that it is very well adapted to the characteristics of the region. It is comfortable with the climate, has harder hooves than the Fleckvieh, is suitable for suckler cow farming, utilizes the growth very well during the grazing period and calves more easily than many other cattle breeds. Because of these qualities, it is also suitable for grazing the poorer locations in the Rhoen (mountain meadows, neglected grasslands).

In addition to this is the fact that it is a traditional local cattle breed from the Bavarian Rhoen which was once found in every stall. In the past, the Yellow Franconian Cattle were closely associated with agriculture in the Bavarian and probably the Thuringian part of the Rhoen, similar to the Rhoen sheep (Richter 1997). It has the same local recognition in the region as the Rhoen sheep and so in the future could be seen as a popular symbol in a similar way for the Rhoen cultural landscape.

The Yellow Franconian Cattle (Fig. 8.12) are also very suitable for marketing purposes as a typical regional product from the Rhoen, analogous to Rhoen sheep. Because there are currently a large number of farmers with suckler cows and bullock fattening who are occupied within the framework of the Biosphere Reserve projects ‘Rhoen Biosphere cattle’ and ‘Rhoen grazing oxen’, the objectives of re-establishing the Yellow Franconian in the Rhoen could be set on a broader basis as in the case of the

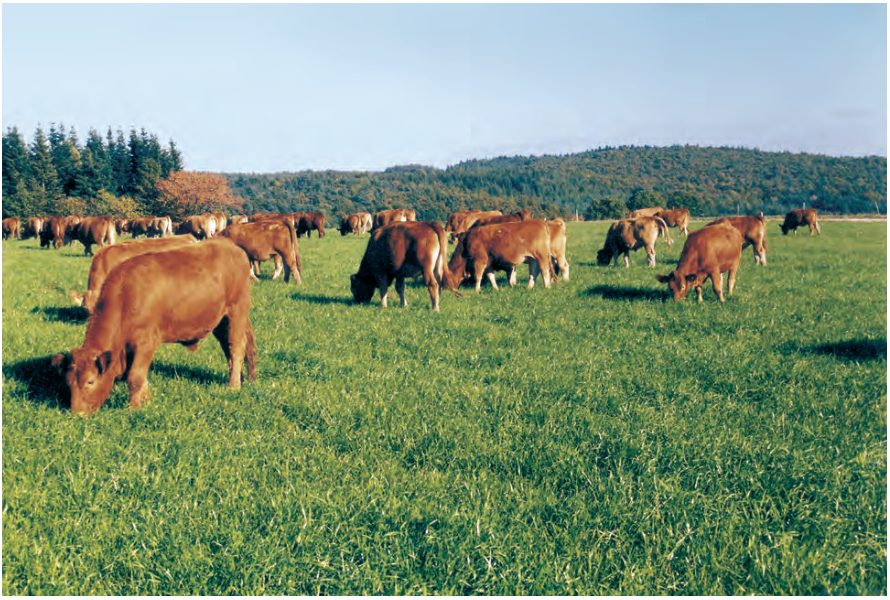

Fig. 8.12. Yellow Franconian Cattle (photo: K.-H. Kolb)

Rhoen sheep. In this way, not only would a few farmers profit from raising and marketing of the Franconians, as is always the case with Rhoen sheep, but there could also be a degree of wider appeal corresponding fully with the objectives of the Biosphere Reserve of preserving and further developing the Rhoen cultural landscape for the people who farm there.

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8.5

A Decision Grid for the Establishment of Livestock Grazing in the Central European Low Mountain Ranges

Harald Plachter

8.5.1

Outline of the Problem

Because of locational differences in production conditions, there are increasing spatial disparities in the type, intensity and viability of agriculture practiced today in Europe. In most of the so-called 'peripheral areas', agriculture is already unviable or will be in the near future (see Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft 2004; Statistisches Bundesamt 2002). All of the low mountain range areas are particularly included here. Central Europe is especially affected by this development because the proportion of land in hilly regions with heights between 500 m and 2 000 m a.s.l. is comparatively high and there is a concentration of the regional species diversity, mainly associated with semi-open mosaic landscapes with a predomination of farming use (Bignal and McCracken 2000; Deutscher Rat für Landespflege 1997; Flade et al. 2003; Phillips 1998; Plachter 1999; Tubbs 1997).

It is also important that the current farming enterprises are dependent on crop cultivation and therefore on land-related production systems to a great extent, not least because of the existing subsidy structure. This is also true in principle for livestock farming, which although it has increasingly operated independent of farmland in the last few decades, has lead to huge levels of environmental pollution in this form. However, new guidelines on 'good agricultural practice' (see clause on 'sensible balance between livestock production and crop cultivation' in §5 Federal Law on Nature Conservation; Plachter et al. 2005) tie even this form of production closely to the land. Farming enterprises in the low mountain ranges are disadvantaged in two respects here: on the one hand, through the climatic limitations on crop cultivation (which also excludes sufficient feedstuff quality for livestock farming) and on the other hand, through the distribution in many regions of inadequate farm sizes.

A withdrawal of traditional mixed farming systems from such regions could also be considered as an ecological opportunity for the aim of allowing a natural development (wilderness area) of ecosystems and landscapes, something now extremely rare in Central Europe (see Riecken et al. 2004). The current reality alone is sending out other signals: farm abandonment has not led – in contrast to southern Europe – to permanent fallow areas, natural succession and 'wilderness', but to ecologically and economically questionable afforestation, land leasing to other enterprises and with that, area concentrations, all of which leads not uncommonly to greater intensification of land use on the remaining farmland (see scenario 2 in Sect. 8.2).

8.5.2

Alternatives

From the perspective of nature conservation, such a development is very alarming: the landscape biodiversity will be degraded in the foreseeable future, natural processes will as before be obstructed (this time through afforestation) and the number of farmers, potentially 'landscape stewards', will reduce rapidly. In the given situation, a more target-oriented approach would be through the clear separation between:

- Landscapes in which there is actually no longer any economic reason for a continuation of the current agricultural use and in which few other requirements are present which support their keeping open (e.g., tourism/recreation) and/or which have a particularly high natural development potential.
  → future wilderness landscapes
- Landscapes in which a new orientation of the EU agricultural policy (with a clear focus on environmental benefit, recreational use, groundwater protection or the preservation of important European ecosystems) associated with appropriate reward for landscape stewardship measures will make farming appear more viable.
  → rural cultural landscapes of the future
- Landscapes in which other land uses are in the foreground because of the favorable local conditions. Such a concentration of production-oriented agriculture and forestry can lead to a reduction of pressure on other landscapes. Pure wilderness areas would then exist alongside almost pure production areas; these, however, should in any case fulfill the basic conditions of sustainable development (see Plachter et al. 2005).
  → agri-landscapes and forest landscapes of the future

Which development will make an impact in a particular region can only be decided through considering all the relevant starting conditions. Guidelines and decision grids which could give an orientation toward the basis of such a spatial separation are much more complex than can be indicated here (Plachter and Korbun 2006; Plachter et al. 2003). Targeted suggestions must not only include ecological aspects, they must also give equal consideration to economic and social aspects, and in addition, to locational factors, with the objective of placing responsibility for landscape development more strongly in the hands of the local population (see Europarat 2005; Deutsches MAB-Nationalkomitee 2004). In addition to this, land planning and political decisions play an important role with respect to:

- potential nature conservation value (the increase in value to nature conservation through fallowing and succession could be low or even counterproductive because of 'neighborhood effects' such as spruce encroachment, through seed spread from neighboring forest monocultures or no-longer existent 'colonization sources'),
- tourist potential/infrastructure for recreation (e.g., restaurants, transport connections),
- significance as a water supply resource (grassland has a higher rate of groundwater replenishment than forest – that is, woodland often increases the retention of precipitation compared to grassland),
- 'retained areas' for future open-land uses which are not currently specified,
- the question as to whether production in peripheral areas is absolutely desirable in a Europe which is generally over-supplied (and increasingly so through expansion).

8.5.3
Keeping Open Rural Cultural Landscapes through Livestock Farming

Only after the decision over the basic objective determination of a landscape has been made can questions be asked about the type of instruments necessary for the realization of the corresponding targets (model decision; see Plachter et al. 2003). If the model for a particular landscape determines the preservation of a semi-open, widely used character (see e.g., Losch and Dosch 1997; Luick 1997; Riecken et al. 1998; Schumacher 1995), there are still quite different land use and stewardship variants available. Livestock farming, associated with large-scale grazing, is only one of the possible alternatives. Because of the proved advantages of this, however, it should be given greater consideration than hitherto. It should also be taken into account that livestock farming – as an agricultural operation – is a 'production system' and as such cannot lose out through the need to keep animals on a particular area of grassland. A proper system of agricultural livestock keeping includes the production of additional feedstuff, and with that, the necessity of maintaining meadows or fields. In this way, further parts of the landscape are kept open and at the same time, the landscape diversity is increased (Plachter 2004).

Large-scale livestock farming is therefore in no way a general 'agent of choice' in 'peripheral areas'. Decisions in this respect are only possible based on the local situation. In the overall context, however, clearer decision-making criteria than have hitherto been available are necessary, also with regard to livestock farming. They focus on the key questions of *where* large-scale livestock farming outdoors is appropriate and *how* it should be carried out. Therefore, a decision grid for the establishment of large-scale livestock grazing was developed based on the findings presented here. However, even this decision grid cannot be accorded general validity. It is tailored to the situation in the Central European low mountain ranges and as such should be understood not as a final 'last resort' but rather as a guideline for a locally-adapted decision-making process.

8.5.4
Decision Grid for 'Large-Scale Livestock Grazing'

The basis of this decision grid is a systematic evaluation of the available literature, the findings presented here and the expert knowledge assembled within the framework of the project. This procedure is sensible as in the course of the particular decision process, normative stipulations must be repeatedly made (e.g., land size, stocking density etc.). Such decision processes have generally proved themselves in our society by operating in standardized, open and legally comprehensible stages (see Plachter et al. 2004).

Corresponding aids to decision-making can be developed with various levels of scientific precision and degrees of complexity. Within the scientific sphere, models which are as 'exact' as possible are the norm (see Zander 2003). They offer a maximum level of robustness but are often very distant from the triviality of daily practical decisions and the preparedness of decision-makers to familiarize themselves with the situation. The following decision grid is correspondingly simple and – assuming good will – generally designed in an understandable way (c.f. Heidt and Plachter 1996;

Müssner and Plachter 2002). However, this does not mean that local scientific findings would therefore be obsolete as the basis for decisions. 'Good agricultural practice' is found not only in the use of nature but equally so in decision processes which determine specific land use variants and with that, ultimately over the development of landscapes.

Such a decision grid can by no means be confined only to nature conservation criteria in the classical sense (particularly species and ecosystem protection) or local characteristics. Ultimately, economic and social criteria will decide over relevant land use variants. These have to be considered accordingly and in fact are key in setting the first decision stages. If a tendential decision for large-scale grazing is likely to be rejected, it is important for the operator to recognize and evaluate alternatives. The decision grid therefore includes information about alternative management strategies, although these are not considered here because of the thematic focus on livestock grazing.

A 'decision tree' was therefore developed with dichotomous 'yes/no' questions, which on the one hand shows distinct and clearly understandable pathways to decision results and on the other, protects against the possibility of false decisions with the use of 'feedback loops'. Such a system must without doubt greatly simplify the reality. Whether a system like this is applied properly or not depends to a large extent on the competence of the individual user. The decisions over the majority of the questions require a background expertise on nature conservation and agriculture, and almost always require extensive empirical data on the area for which decisions are needed.

Simple yes/no decisions would, however, greatly simplify the existing problem so that a proper judgment would hardly appear possible. For this reason, additional 'suitability classes' for different land use and management variants are included which logically and clearly arise from the particular questions. However, the limitations of these suitability classes have to a large extent a normative character. At present, this class formation only has a suggestive character because it is not yet broadly validated at expert level.

The decision grid processes two spatial levels:

a the landscape level (as an ecologically functional and use-technical unit), and
b the individual areas (in the sense of a unitary area of vegetation, for example, grassland)

Missing from this, as an independent decision factor, is the farm level and with that, the level at which the farmer is the main decision-maker, assuming freedom of choice. In the form presented here, the decision grid is therefore more of an assistance to strategic planning than a guide to action oriented to farm level. It is based on fundamental conditions which must be present for the implementation of large-scale livestock grazing in a landscape or a specific area.

8.5.5
Criteria for the Decision Grid

The landscape in which livestock grazing is appropriate must fulfill the following conditions:

1. The available agricultural subsidies over the next twenty years should be sufficient to offer to farming good to satisfactory chances of survival (see Hampicke and Roth 2000).

   If farming in the region is not viable under the existing and expected framework conditions, then large-scale grazing cannot be brought into farm enterprises and is only possible as a stewardship measure for nature conservation, missing the objective of a land use appropriate to ecological, economic and social requirements. The dead-end into which the so-called 'nature conservation agreements' have foundered after thirty years of respectable success (financial shortages, insufficient farm adaptations, increasingly growing area of 'responsibility') underlines this clearly.
2. Agri-environmental subsidy and/or nature conservation agreements should be able to play a significant role in the stabilizing of farming enterprises.

   Nature conservation and landscape stewardship should be understood by all representatives of agriculture as an 'obvious production output'. Without these subsidy instruments, large-scale livestock grazing cannot compete with conventional systems. They give planning security to the individual enterprise which must cover investment expenditure possibly over decades.
3. Livestock farming should already play a significant role in the affected farms (also in the recent past of the farms).

   A switch from a purely arable enterprise to livestock farming would lead to fundamental adaptation processes which could only seldom be properly justified by an expected gain for nature. Additionally, it can be assumed that the preparedness of the farmers to give up their traditional forms is very low.
4. Over the last 200 years, there should have been large-scale grazing systems at the landscape level.

   The implementation of large-scale livestock grazing is not appropriate in landscapes which are not characterized by grassland because other landscape models are relevant there and they would 'falsify' the – historically developed – character of the landscape. Additionally, the potential of colonization for new meadows and pastures are as a rule small. An exception may be the traditional grazing regions which only experienced a major change in use during the last few decades.
5. The landscape structure should still retain remains of the old large-scale grazing system.

   Particularly for landscapes, in which large-scale grazing system structures are recognizable (e.g., former common grazings, grazing strips on valley sides as in the Black Forest or parts of the Rhoen) are suitable for the (re)introduction of large-scale livestock grazing. Only in this way can the variety, uniqueness and beauty of these landscapes be assured over the long term (see §1 BNatSchG – federal law on nature conservation in Germany).
6. The local farming enterprises should have the technical capability and organizational capacity to set up large-scale livestock grazing.

   Livestock grazing is only socially and economically appropriate through the inclusion of the existing farm enterprises – then it can preserve farms and jobs and promote identification with the region, which is desirable for nature conservation.

7. The farms should also be able to operate viably if the feedstuff is produced from local land and further processing and marketing is mainly carried out locally.

   As a counterbalance to a spreading globalization, agricultural production is appropriate which produces qualitatively high-value goods and thereby is kind to nature, among other things in that it uses regional (and therefore energy-saving) material and energy sources. In Germany alone, more than 300 labels of approval for regional products confirm this trend. Large-scale grazing should take this into account as well as the classical objectives of species and ecosystem protection.

Within the landscapes which are to be assessed, the existing or potential grazing lands should fulfill the following conditions:

1. The land must be in the ownership of farmers or be capable of leasing to such under favorable conditions.

   Suitable alternatives include land in public ownership as well as new or existing lands managed by user communities. Particularly for farms operated as secondary occupations, a cooperative user group can represent a work-time extensive and capital extensive form of management. The taking in of pensioned cattle is a further management option.
2. There should be at least a moderate colonization potential for grassland species characteristic of the landscape.

   If the colonization potential is low and cannot be improved through the use of roaming sheep flocks or technical measures (e.g., the spreading of autochthonous mowed grass materials), then grazing can only be recommended if all other options (e.g., fallowing) would have a clearly more negative effect. According to all available information, grazing which is beneficial to nature conservation can only develop in isolated locations over the long term.
3. Typical pasture habitats (woodland edges, stones, walls, water bodies) should at least have a fragmentary presence or be capable of development with a low amount of input.

   The local diversity of large-scale pastures results from the varied behavior of the grazing animals and this is closely associated with the structures and habitats typical of the pastureland. If these are absent, then some of the behavior forms would be completely missing (e.g., grooming behavior with woody vegetation) or would be carried out with no spatial differentiation (e.g., grazing). For the desired improvement of existing location gradients (e.g., nutrient distribution through separated grazing and defecating areas), these must be present from the start.

8.5.6
Implementation of the Decision Grid

The decision route for a land use or management form is highlighted in gray and branches leading to other alternatives are highlighted in different colors. With respect to the objective orientation for specific variants, there are 6 different 'suitability classes' ranging from 0 = unsuitable to 5 = suitable without restrictions. At the end of the branches of the decision tree, there are 6 different classes (0 to 5) of suitability for large-scale grazing. More details are in the text.

A	ASSESSMENT OF THE LANDSCAPE	
(1)	Does the agriculture in the landscape area have good to satisfactory survival chances for the next 20 years with the given farm subsidy conditions?	**Y (2)** N(A1)
	(A1) Is there a general preparedness to purchase or lease the existing farm enterprises?	**Y(A3)** N(A2)
	(A2) Are there large interconnected areas in the landscape area owned by the state or by nature conservation groups?	**Y(A3)** N(B1)
	(A3) Is there a preparedness from at least one of the farms to take part in nature conservation management for financial reward?	**Y(A4)** N(B1)
	(A4) Is a large-scale unpartitioned section of the area in existence?	**Y(A5)** N(B2)
	(A5) **Conclusion:** The area is not very suitable for large-scale livestock breeding in normal farming enterprises. Large-scale wild keeping of herbivores, however, is possible (***CLASS 1***)	
	▶ **Recommendation:** Wild, all-year outdoor keeping of robust domestic breeds or large wild animals/re-breeds	
	(B1) **Conclusion:** The area is not suitable for the large-scale keeping of herbivores or such a use would require an unacceptably high expenditure (***CLASS 0***)	
	▶ **Recommendation:** Await further development, land purchase for future nature conservation use. Current objective: process protection	
	(B2) **Conclusion:** The farm-relevant preconditions are present. The land availability is not favourable (***CLASS 2***)	
	▶ **Recommendation:** Scheduling of a land consolidation project	
(2)	Can agri-environmental subsidies and/or nature conservation agreements play a significant role in the economic stabilisation of the farm enterprises?	**Y (3)** N(A1)
(3)	Does animal keeping in the farm currently play a significant role?	**Y (4)** N(C1)
	(C1) Do rational possibilities exist to convert the farms (partially) to livestock farming?	**Y(C2)** N(B1)
	(C2) **Conclusion:** The area is basically suitable for the development of large-scale livestock farming. For this, favourable framework conditions need to be created first of all (***CLASS 3***)	
	▶ **Recommendation:** Targeted farm advice. Land purchase for nature conservation purposes and availability as pastureland for farms. The take up (if not already done) of state support programmes in the area. Financial support for farm structural conversion via structural funds	
(4)	Have there been large-scale grazing systems in the landscape area in the last 200 years?	**Y (5)** N(D1)
	(D1) Is the new development of grazing systems ecologically appropriate? (landscape-ecological structure, colonisation potential)	**Y(D2)** N(B1)
	(D2) Is there already here the necessary ownership structure (including land in state ownership)?	**Y (E1)** N(D3)
	(D3) Can suitable ownership structures be made available through land exchanges (inc. public land) and/or land consolidation?	**Y (5)** N(B1)
(5)	Are there any structural historical remains of the landscape still in existence? (former common grazings, grazing strips etc.)	**Y (6)** N(E1)

(6)	Is traditional sheep farming still carried out? (roaming flocks, herded keeping)	**Y (7)** N(E2)
(E1)	Is there still awareness of these 'historical' land use forms in the local population?	**Y (E2)** N(E3)
(E2)	Are there any priority development needs on large grassland areas with respect to 'agricultural principle'?	**Y (7)** N(B1)
(E3)	Is there a basic preparedness within the local population to reorient the enterprises to nature conservation goals (if need be, connected with production of quality products)?	**Y (E4)** N(B1)
(E4)	**Conclusion:** The basic conditions for the restitution/introduction of large pastures are 'moderate' (***CLASS 3***)	
	▶ **Recommendation:** Closer analysis of the local situation and perhaps further with (7)	
(7)	Are there any farm enterprises which are capable of setting up large-scale pasturing at an individual level?	**Y (8)** N(F1)
(F1)	Is there a basic preparedness to consider cooperative forms of farming? (common grazings, shared winter stalls etc.)	**Y (8)** N(F2)
(F2)	Can sufficiently large land areas be made available for individual farms through leasing?	**Y (E3)** N(F3)
(F3)	**Conclusion:** Because of its history, the area is basically capable of reintroducing suitable, large-scale pasturing. However, the farm structures are not favourable, nor is the commitment of the farmers	
	▶ **Recommendation:** Less suitable (***CLASS 2***). Only to be further pursued if there are very pressing reasons, e.g. management of priority species	
(8)	Are the farm structures still sustainable if the feedstuff is largely produced on local land (purchase of concentrate only for milk production)?	**Y (9)** N (G)
(G1)	Has the possible farm structure foreseeably significant effects on the nutrient balance of the pastures?	**Y(G2)** N (9)
(G2)	Do forecasts confirm, however, that with regard to the respective area, a relatively species-rich biozoonoses can be expected (balance compared to other ecosystems in the area?	**Y(G3)** N(B1)
(G3)	**Conclusion:** The area is well suitable albeit with certain restrictions (***CLASS 4***)	
	▶ **Recommendation:** Continue to (9)	
(9)	Are there sufficiently large connected areas on the slopes (at least 50 ha) which can be made available for pastureland, or which already consist (at least partly) of grassland?	**Y (10)** N(H1)
(H1)	Can land be made available through woodland clearance to a moderate extent and/or through closure of minor roads to public traffic?	**Y (10)** N(K2)
(H2)	Could smaller grazing plots for young cattle and/or sheep and/or mixed grazing also offer a benefit to nature conservation with the condition that no fertiliser is applied?	**Y(K3)** N(B1)
(H3)	**Conclusion:** Unsuitable for large-scale grazing (***CLASS 0***)	
	▶ **Recommendation:** support for smaller set stocking pastures, if this is justified by the landscape orientation	
(10)	**Conclusion:** The landscape area is suitable ('good' to 'very good') for the maintenance or establishment of large-scale grazing systems (***CLASSES 4 or 5***)	
	▶ **Recommendation:** Continue with area analysis **(section B)**	

B	ASSESSMENT OF THE INDIVIDUAL (POTENTIAL) PASTURES	
(11)	Is the land in the ownership of farmers who are prepared to cooperate?	**Y (12)** N(K1)
	(K1) Is the land in public possession (state, communities)?	**Y(K2)** N(K3)
	(K2) ▶ **Recommendation:** Leasing to local farmers on favourable terms	
	(K3) ▶ **Recommendation:** Look for alternative land	
(12)	Is there a 'very good' to at least 'moderate' colonisation potential for grassland species characteristic of the landscape 'locally' or from surrounding ecosystems?	**Y (13)** N(L1)
	(L1) Can the colonisation potential be improved through connection with roaming sheep flocks and is this compatible with the usual, station keeping conditions?	**Y (L3)** N(L4)
	(L2) Can the biodiversity of the pastureland be supported through eco-technical measures (turf transfer, mowed materials spreading, settlement)?	**Y (L3)** N(L4)
	(L3) **Conclusion:** The area is relatively suitable for the establishment of large-scale pasturing (***CLASS 4***). However, the development potential can still be improved	
	▶ **Recommendation:** Preservation or establishment of large pastures to be pursued	
	(L4) **Conclusion:** The land is only moderately suitable for the establishment of large-scale grazing (***CLASS 2***)	
	▶ **Recommendation:** Only to be pursued if the qualitative comparison with alternatives (continuation of current land use, fallowing) indicates clear benefits	
(13)	Are there at least residues of pasture-typical habitats (woodland edges, stones, walls, Streams or other water bodies) on the (potential) pastureland?	**Y (14)** N(M1)
	(M1) Can such habitats be naturally developed with the use of local materials?	**Y(M2)** N(M3)
	(M2) ▶ **Recommendation:** Establishment of such habitats to increase value	
	(M3) ▶ **Recommendation:** Look for possibly more suitable land	
(14)	Is the land suitable for the keeping of young cattle or heifers and does such a use fit with the local farm structures?	**Y (15)** N(N1)
	(N1) Can other grazing systems be considered (sheep, mixed grazing, hobby farming etc.)?	**Y (15)** N(N2)
	(N2) Is it possible to set up 'landscape stewardship farms' which would follow exclusively nature conservation objectives?	**Y(N3)** N(N4)
	(N3) **Conclusion:** Although the area is very suitable, large-scale livestock grazing cannot be integrated into the existing agricultural production structure	
	▶ **Recommendation:** Creation of landscape stewardship farms with clear public support	
	(N4) **Conclusion:** Areas and fields are very suitable. However, the establishment of large-scale livestock grazing is not possible	
	▶ **Recommendation:** 'wild keeping' (A5)	
(15)	**Conclusion:** Area, fields and agricultural structure are perfectly suited for large-scale livestock farming (***CLASS 5***)	
	▶ **Recommendation:** Priority implementation of such pasturing or animal production systems	

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Chapter 9

Nature Conservation Accounting for Large-Scale Livestock Grazing

9.1
Starting Position

Globally, nature conservation over the last 50 years has largely been characterized by segregated, preserving strategies (Plachter 1995). This was by no means always the case, at least for European nature conservation. A holistic approach related to landscape was one of the roots of nature conservation in the first place, as is expressed even now in the dual term 'nature conservation and landscape stewardship'.

After the Second World War the necessity of preserving the particularly valuable elements was so obvious and urgent that other tasks had to first of all take a back seat. In addition to this was the fact that any change to the general trend towards intensification on land already used in the atmosphere of mechanization and maximization euphoria at that time had very little chance of succeeding. However, the forced neglect of agricultural approaches has had its effects up to today, as seen in the persisting crisis in landscape planning.

Only in the last few years, and following considerable pressure, have landscapes again become an important object of nature conservation (Deutscher Rat für Landespflege 1997; Haber 1999; Konold 1996; Philipps 1998; Plachter and Puhlmann 2004; Schumacher 1995). Ecological findings are one of the triggers: it became clear that even with the numerous reserves set up in the meantime (nearly 12% of the world's land surface; *www.iucn.org*), the variety of species and ecosystems could hardly be effectively maintained in the long run, if fragmentation and isolation prevented basal ecological processes taking place in the intervening 'matrix'. The establishment of 'corridors' was invented as a 'counterstrategy' (Burkhardt et al. 2004; Jedicke 1990). Another strategy was intended to put this matrix itself in a condition allowing many species at least a temporary survival and the chance to migrate from one 'permanent habitat' to the next one (Henne et al. 2003; Plachter et al. 2005).

On the other hand, society's demands on landscapes have changed radically in the last few decades. Where there was a clear emphasis on production quantities at the start of the 1950s, now we have product quality requirements and recreational demands following several 'agricultural crises' and the recognition that quantity is not the most decisive factor if it may cause illness. This also includes the living area as shown through an increasing migration out of the towns and towards rural areas.

Now it turns out that our knowledge of landscape and our protective strategies for an appropriate landscape development are largely incomplete. Landscape is a far more complex arrangement than just individual ecosystems and it is subject to a permanent dynamic and change. There is hardly any sense in applying exclusively conservation strategies, particularly in cultural landscapes (see Plachter 2004). It would be absurd to forbid the use of certain technical innovations by the local population only because this could mean a threat to the ecological values. It is dependent on whether and how specific land use technology is to be used in specific areas.

Therefore, the political theory of 'sustainable development' is at the Center of modern landscape conservation, more so than in any other area (see Haber 1998; Plachter et al. 2004b; Rat von Sachverständigen für Umweltfragen 1996). In Central Europe, this normally means continuing as before in another form, not least because this is associated with positive effects on the landscape pattern. The search for an optimal compromise between social, economic and nature conservation demands on the landscape has become a central task for nature conservation. From the point of view of ecological and societal considerations, there can be no 'general' compromise. The local conditions and the existing biotic inventory are too different, as are the social and economic requirements of the particular area. The recent 'Landscape Convention' of the European Council is aware of this, if not very clearly defined, and has settled on subsidiarity and re-identification of the local population with 'their' landscape, similarly to the general EU policy (*www.coe.int/t/e/Cultural_Co-operation/Environment/Landscape* 2005).

In the last few years, there has been increasing discussion on the grazing of herbivorous mammals as a cornerstone of sustainable landscape development (see e.g., Finck et al. 2002; Kampf 2002; Luick 1996; Oppermann and Luick 1999; Plachter et al. 2004a; Pott and Hüppe 1994; Redecker et al. 2002; Völkl 1997). This is appropriate because on the one hand, plant-eating wild animals played an important role in the prehistoric landscapes of Europe and still do in many parts of the world, and on the other hand, livestock grazing was probably the land use form which had the greatest influence on landscapes over thousands of years in Europe. The majority of the present-day priority protection ecosystems in Europe were subject at some time to livestock effects or are even largely formed by them (see Plachter 1996).

Even though the findings are basically unambiguous, the detailed conclusions derived from these are heterogenic and contradictory. The current discussion on 'herbivores as landscape managers' is threatening to deteriorate into an argument over which side can produce a generally suitable 'optimal solution'. However, it is exactly this which cannot be produced, and frequently, the purpose of proposed management strategies are not addressed clearly enough. These can be very different:

- Complementing existing semi-natural ecosystems with the 'natural' components herbivorous mammals (e.g., through re-colonizations in national parks).
- 'Renaturalization' of semi-natural or abandoned areas, in the sense of 'wilderness' (e.g., beavers in river plains, large herbivores in abandoned military training sites);
- Management of semi-natural ecosystems, which (also) have arisen through grazing, applying a definite, land-related objective (e.g., protection of specific plant species which cannot tolerate other management forms);
- Controlling succession, which in Central Europe would normally lead to woodland (e.g., browsing of woody vegetation with goats);
- Alternative 'semi-natural' production forms with the objective of maintaining an economically sustainable local agriculture (e.g., quality products);
- Contributing to 'landscape management' with the objective of preserving diversely arranged open landscapes with moderate woodland areas (e.g., roaming sheep flocks on the Swabian Albs).

Of course, several of these objectives would often have simultaneous significance in specific landscapes. They then need to be specified at the individual location (on the specific land) and prioritized in the case of conflict. There are no grazing forms which generally support all objectives.

The suggestions presented here on grazing with wild or domestic herbivores cover a very wide spectrum of different variants (see e.g., Eckert 1992; Fischer 1995; Gallunder and Ludwigs 1994; Kampf 2001; Krüger 1999; Martin 1997; Putman et al. 1991; Redecker et al. 2002). It stretches from the unmanaged 'wild' keeping of wild animals and semi-wild domestic breeds to modern forms of keeping on small-scale rotational pastures, from a nature conservation management which is (almost) completely financed with public money, to a corresponding structuring of local agricultural enterprises, from grazing as an 'additional accompanying measure' to grazing as a factor which determines development, from the experiment of preserving existing pastures (usually through livestock), to the legal prohibition of such forms of use, from the active hunting of herbivores (e.g., roe deer, red deer), to their conscious promotion as 'managers'.

If one puts ideas of sustainability in the foreground, then the key question is: are there any grazing variants with livestock at all which simultaneously develop positive ecological effects at ecosystems and landscapes, support the preservation of existing agricultural enterprises and fulfill modern societal demands on landscapes?

9.2
What We Can Learn from 'Historical' Grazing Systems

There is no doubt that grazing, whether through wild animals or domestic livestock, has contributed decisively to biodiversity in Europe. Without these influences, many landscapes in Europe would be largely wooded, in some cases with a high species variety but with a completely different species range as we find in the present day.

Production-oriented livestock farming in Europe was, and with all the modern restrictions, still is, extremely varied. The spectrum extends from semi-wild keeping of reindeer in northern Europe to 'modern' stall keeping of dairy cows which produce more than 12 000 kg milk per year of output, from mixed use forms with multi-functional uses of woodlands and meadows to production of feed maize for stall animals, from domestic breeds such as cattle and ducks to 'exotics' (archeozoa and neozoa) such as sheep, goats and turkeys.

In historical systems of land use, all variants have in common that a part of the feedstuff requirement of the herbivores is covered by outdoor grazing. As trivial as this observation may seem at first glance, it is important for the understanding of the ecological consequences. Livestock serve to meet the physiological requirements of humans with animal proteins. Through this way, and not through the direct consumption of plant products, the largest part of the feedstuff energy intake must be directed to maintaining the grazing animals and only a small part results in the output desired by humans, for milk and meat. Despite this, these characteristics have meant that grazing livestock has become one of the most significant factors in forming the landscapes in many parts of the world.

The problem of the comparatively poor nutrient utilization by herbivores (in comparison to the energy and nutrient content of the plants themselves) was not unknown to our ancestors. They therefore invented ways, in the sense of technical utilization, to improve this unfavorable balance; in nomadic societies, by using livestock excrement for a variety of purposes (e.g., as a fuel); in static and semi-static societies typical in Europe since the 'Neolithic Age revolution', through the spatial separation between nutrient uptake and excretion and therefore, the possibility to use animal feces along with degradable plant material (tree cuttings, sods etc.) as a 'natural fertilizer'. The necessary consequence of this was the overuse of the pastureland (grassland, woods) because the second nutritional basis for humans – the crops – was almost always in short supply.

Nowadays, we evaluate the ecological results completely differently to our ancestors. Even 200 years ago, nobody would have hit upon the idea of classifying a woodland pasture as 'valuable' and 'worthy of protection'. However, the technical innovations of the last 200 years were 'better' and 'more efficient' than expected. The problems around at that time concerning soil conservation and woodland degradation have now been largely solved in Europe – or could be solved without further ado, if one only applied the available knowledge. Inevitably, however, these 'overused' systems are now disappearing, along with the species that found a 'second home' in such grazed habitats, whatever primary, already destroyed habitats they may have once occupied. This in no way applies just to the pastures alone. It affects almost all woodlands and it also affects one of the most species-rich formation types in Europe, the meadows.

Meadows are mowed grassland. They are established with only one purpose: for the production of additional feedstuff for livestock. If modern livestock farming no longer needs this (e.g., because the feed quality is too low), then the purpose of meadows comes into question, and with that, the species which may have colonized them. A continued use of meadows without utilization of the vegetation biomass would only have a museum value.

Concerning the land use in Central Europe in the historical period, there exist only relatively general, hazy conceptions (e.g., from literature and chronicles). In the discussions about nature conservation, they are loaded with emotional values in which key concepts such as 'extensive', 'environmentally aware' or 'small-scale' play a significant role.

At present, the former Soviet Union offers a very good, perhaps even unique example of the construction of the old land use forms in Central Europe: societal structures and cultural roots (and with that, decision norms), climate and livestock breeds in some areas are similar to those in Central Europe in the not-too-distant past (see Didebulidze and Plachter 2002; Tsaryk and Tsaryk 2002). After the break-up of the Soviet economy and the resulting privatization of agriculture, the supply of food to the family 'from the country' gained increasingly in significance. Production for national and international markets lost in importance while money and machines had very little meaning.

After almost 2 decades of this development, the production systems in many rural areas are increasingly matching the 'historical framework conditions' in Central Europe. An analysis reveals the following facts:

- The existing livestock farming systems preserve and actually produce a high biodiversity at the levels of single pastures (as a spatial-temporal arrangement of individual fields) and the landscape level although this is spatially very structured (see Bontjer and Plachter 2002; Satzger 2002).
- Subsistence forms of grazing are consistently associated with considerable damage to specific areas of conservational value (above all, woodland and soils), as was the case in Central Europe over the historical period. Modern 'sustainable' strategies need to find compromises in the sense of an inter-disciplinary alignment.
- Such systems of land use cannot be integrated in their entirety into western systems of production. This is the case not least because of the very high personnel input associated with low productivity arising from lack of available resources (livestock breeds, basal machinery) and the desolate income situation which is orders of magnitude away from that in Western Europe (see Sect. 7.4).
- Single elements of this (e.g., communal work division, spatial-temporal variance) with significant ecological effects are however, worthy of greater consideration for inclusion in western production systems than has hitherto been given.

One of the perhaps most significant results is that there cannot be a 'maximum biodiversity' with at the same time, a 'minimal erosion and water pollution'. This is in fact already known from the historical sources in Central Europe. Livestock grazing has then only significant influences on biodiversity when it is 'strong' enough to disturb or interrupt the other, natural courses. Because it also has a decidedly heterogeneous effect on large areas because of the animal behavior, this must result in local 'over-use' consequences. This means that the effects on the individual conservation goods have constantly to be weighed up in each case.

However, because of a big shortage of resources, subsistence systems are also focused on an optimization of production resources, possibly much more so than western industrialized systems. Here, among other things, four significant effects show up:

- the amalgamation of communal division of labor techniques;
- labor saving through the use of animal behavior;
- the use of a significantly broader spectrum of pasturelands;
- a longer period of outdoor keeping over the year.

A consequence of this is the amalgamation to form systems similar to common grazings with a communal division of labor, particularly for the herded cattle and sheep systems occurring in the form of mixed 'village herd' enterprises (so long as the former state enterprises do not continue). In contrast, feedstuff production remains as a rule an individual activity, resulting in very small-scale complexes of poor grasslands (unfertilized, mostly hand-mowed) (Fig. 9.1).

Domestic cattle and pigs in particular and all 'modern' domestic breeds in general are assumed to have a very limited behavior repertoire deviating greatly from that of their wild ancestors. This bias is clearly inaccurate. As was shown with the example of Georgia, herded dairy cows join the shepherd who is walking through the street of their own accord in the morning and depart in the same manner in the evening, then are 'taken over'

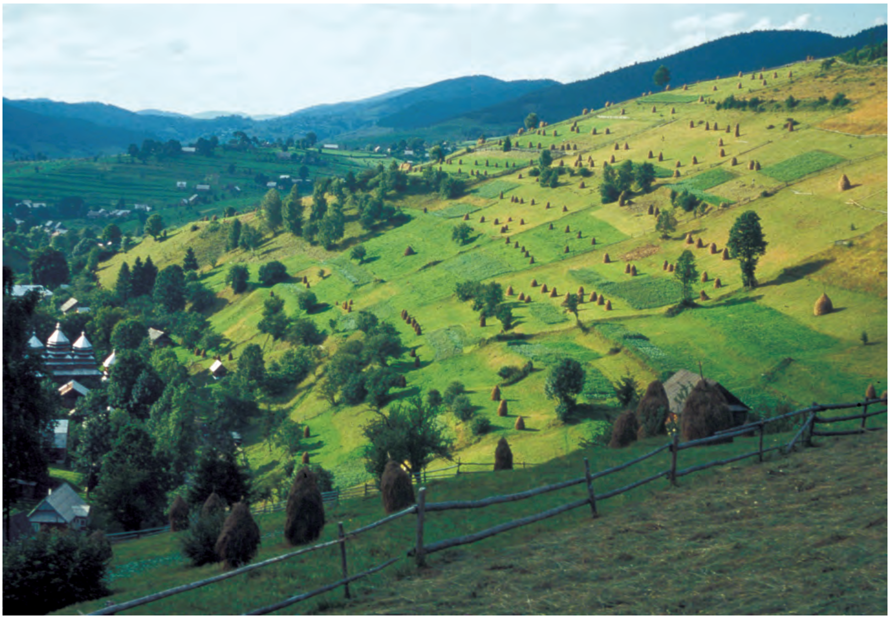

Fig. 9.1. Small-scale meadow landscape resulting from the hay requirement for livestock farming. West Ukraine: Carpathia, upper Opir Valley (photo: H. Plachter)

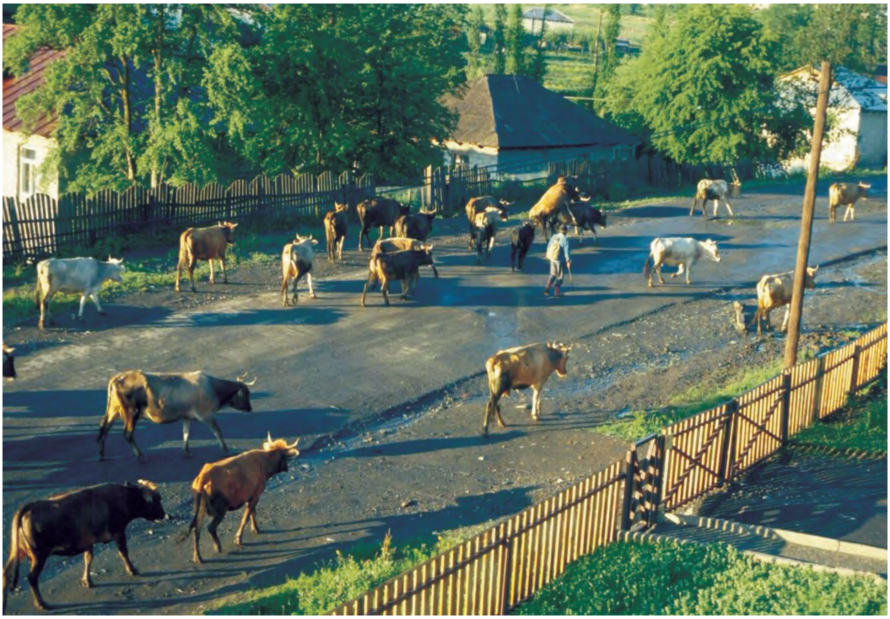

Fig. 9.2. In subsistence herding systems, the cattle of different owners independently group together in the morning. West Georgia: Bakuriani (photo: H. Plachter)

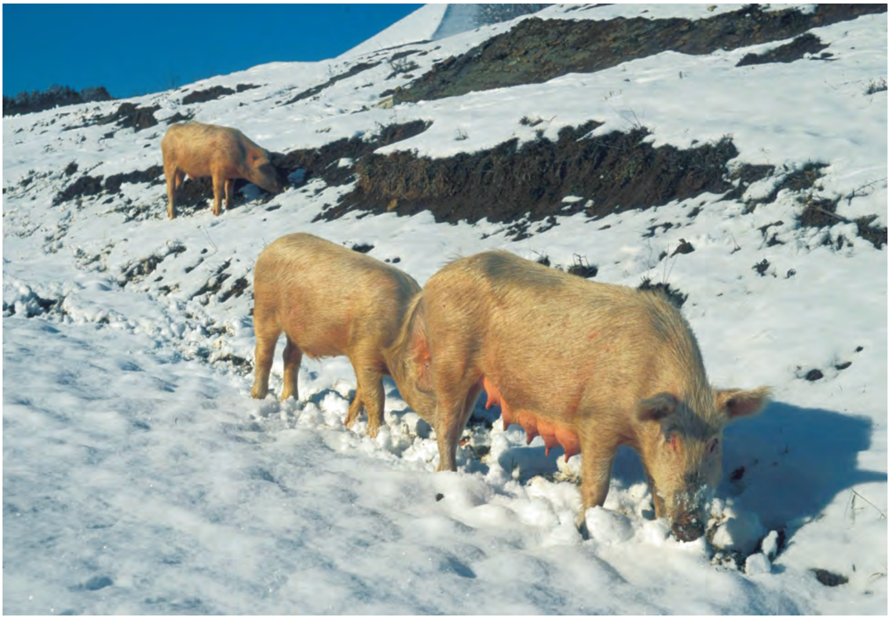

Fig. 9.3. Free range unherded pigs survive also in winter without human management. Central Georgia, west of Tbilisi (photo: H. Plachter)

by the waiting owners (Fig. 9.2). On the pasture, promising areas are deliberately sought out. The domestic pigs are regularly let out free in the morning and feed themselves where they can over the day before returning to the pens in the evening (Fig. 9.3).

It is noticeable, particularly in Georgia, that animal feed is the limiting factor for the livestock levels, despite the ubiquitous pasturing. Among other things, this leads to the fact that for all of the suitable pastures, there is clear separation between the individual livestock species. Cattle enjoy a clear priority in the competition for limited pastureland (milk!) followed by sheep and goats. Pigs mainly use certain woodland types and the areas of cut grass near habitations (roads sides etc.). Ducks and geese prefer to graze on wet grasslands near water sources.

Also in the case of 'semi-wild' unsupervised keeping, this separation has become established, probably because of the behavior and varying requirements of the different species.

9.3
Ecological Effects Dependent of Area Size

The type and extent of the effects of herbivores on a particular vegetation unit or an ecosystem are primarily dependent on the animal species and the stocking density. There is already extensive literature on this relationship on both natural systems and on livestock farming. The spatial extension of the area used by the herbivores as such seems at first to be of secondary or indirect significance, for example, as when it finally determines the stocking density and with that, the land use pressure (as a rule interpreted as grazing pressure). Consequentially, the west European literature relates 'large-scale grazing' necessarily with 'extensive', that is, with an equal number of animals but on a larger area. The fact that the effects can also be different with the same stocking density per area unit following changes in the size of the total area has hardly been discussed up to now. Three general considerations about this relationship can be surmised here:

1. The wild ancestors of our present-day domestic animals (e.g., aurochs, wild sheep and wild boar) are typified by a high demand for space and resources. Some of them (e.g., cattle, ducks and geese) undertook seasonal migrations. The smaller the spatial limitations, the greater are the losses in the natural behavior repertoire, and with that, the confining of the ecological effects. As long as the pattern of behavior is still present, a 'renaturalization' of the form of keeping through an area enlargement can also clearly extend again the spectrum of effects.
2. Highly specialized species are less suitable as livestock (e.g., because of all-year availability of a specific type of nutrition). Consequently, all of our livestock are in principle 'generalists' with regard to the spectrum of utilizable nutrition, but also with regard to other living demands. Such generalists consistently react in the same way: they first of all select from the 'supply' the most suitable resources and use them until this is exhausted, before going over to the next available resource. For this to be possible, there must be freedom of choice between the different resource qualities. Livestock farming has replaced this freedom of choice with the decision of the farmer, with the object of always offering the 'best' resource (in the sense of higher productivity). Put simply: a dairy cow in a tie stall no longer has the choice between different resource qualities, with respect to neither nutrition nor to other behavior manifestations (e.g., resting places, social contact in the herd). Conversely, 'renaturalization' can mean a wide spectrum of ecological effects associated with the form of keeping. This is also necessarily dependent on the area (independent of the 'density') available for the individual animals.
3. In connection with the significance of herbivorous wild and domestic animals, it is mainly their 'grazing effects' (referring to nutritional uptake) which are discussed (e.g., Bruckhaus 1988; Van den Bos and Bakker 1990; Eckert 1992; Gibson and Brown 1992; Hume and Brock 1997; Hüppe 1997; Mückschel and Otte 2001; Putman et al. 1991; Rieger 1996; Scherfose 1993; Schwabe 1990). However, the ecological effects of herbivores are in no way restricted only to the uptake of nutrition but comprise a very wide spectrum of other manifestations, reaching from seasonally different food preferences to the mechanical damage to vegetation and the soil, from grooming behavior without 'basic needs' to the transport of dispersion elements of other species (see for example, Wallis De Vries and Schippers 1994) (Fig. 9.4). This has long been proved for wild animals (e.g., destruction of trees by African elephants, wild pig wallows, 'peeling' of tree bark by red deer). It seems that livestock are not accorded this type of manifestation, at least not in Europe, or if so, then this is automatically classified as 'damage'. However, this is just as important for the diversification of habitats on pastureland as the uptake of nutrition. In order that livestock is able to manifest such types of behavior in spatial-temporal diversity, the material-structural conditions must be present, and this again correlates with the area size and the local heterogeneity of the pastureland.

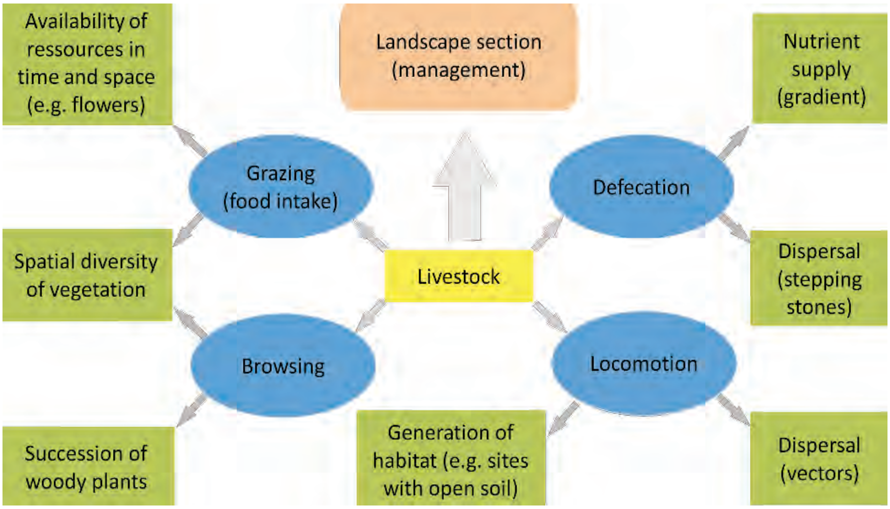
Availability of ressources in time and space (e.g. flowers)
Landscape section (management)
Nutrient supply (gradient)
Grazing (food intake)
Defecation
Spatial diversity of vegetation
Livestock
Dispersal (stepping stones)
Browsing
Locomotion
Succession of woody plants
Generation of habitat (e.g. sites with open soil)
Dispersal (vectors)

Fig. 9.4. Different ecological effects of domesticated cattle on pastures and at landscape level

A direct causal proof of the area-dependent effects of livestock is, however, very difficult to show. According to the species-area relationship, there is a general connection between area size and species numbers (Diamond 1975). The following indirect conclusions and method combinations are revealing:

1. Analysis of the extent, type and seasonal variances of livestock effects on vegetation and selected animal species. Only when these effects are operative with regard to the creation of additional habitats can an impact on the existent species be expected.
2. Analysis of the behavior of livestock with respect to all the living manifestations (not just food uptake) in relation to area size. If the pattern of behavior changes relative to the area, then effects on the spatial-time structure of the habitat and the population can be reckoned with.

It turns out that unherded cattle actually do change their behavior quite clearly following an increase in the size of the area (see Sect. 6.1, 6.3 and 6.6). This is particularly relevant with respect to the following:

- An extension of the spectrum of behavior with regard to social structure, social ties and grooming behavior. Put simply, cattle increasingly take up the behavior pattern of their wild ancestors, such as herd hierarchy with leading animals (even with 'inexperienced' heifers or bulls), behavior synchronization within the herd (simultaneous eating, walking, resting etc.) or protective strategies through the selection of a 'secure' common night-time retreat. With respect to grooming behavior, there is a similar diversification, particularly affecting woody vegetation.
- Greater spatial differentiation of preferred places for specific behavior manifestations. Even if this point could not yet be fully demonstrated for medium-sized pastures in southern Germany (Sect. 6.1), there is no doubt about the finding for

large-scale set stocking pastures on Oeland (Sect. 6.3). Among other things, one consequence is that the amount of walking each day increases correspondingly because distant 'preferred locations' have to be successively visited over the course of the day. Such basic requirements include grazing, drinking, day-time resting (ruminating), defecating and urinating, night-time resting (Fig. 9.5). If the preferred locations for the individual requirements are widely separated, then completely different effects can be reckoned with locally and as a consequence for the whole pasture through a diversification of the habitat structure (two existing habitats of the same type develop differently according to which behavior is manifested there by the cattle).

- Increased behavior-induced seasonal variances of the livestock effects. Cattle prefer specific nutritional types or qualities. It appears that on large-scale pastures, they first of all use the 'best' nutritional sources followed by worse ones. If there is freedom of choice, a scattered pattern of irregularly distributed grazed areas arise initially over the whole pasture and over the course of the year, these are gradually leveled out. In high summer, the cattle concentrate on places near drinking troughs or water sources and shadowed resting places, which as a consequence may be subject to a very high level of damage (Fig. 9.6).

In principle, the same is also true for herded systems with the same species. They basically take place on larger areas. The freedom of choice of the livestock is partially restricted by human control. Conversely, the shepherd also enforces impacts on nature at specific sites which would have been avoided with 'natural' livestock behavior. Again, there is a diverse, albeit modified, spatial-temporal pattern of livestock effects.

Area size per se is then a definite factor which can play a significant role with regard to the effects of livestock. The question naturally arises about the 'optimal' area size. Extremely large pastures make control and veterinary supervision difficult so cause additional costs. Pastures which are too small do not allow the animals to fully unfold their repertoire of behavior, and above all, do not have sufficient spatial-temporal sepa-

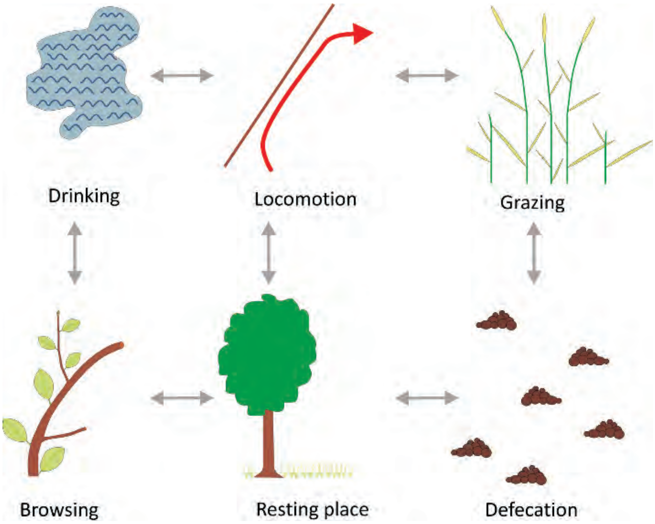

Fig. 9.5. Spatial separation of central life requirements of cattle on a large-scale pasture

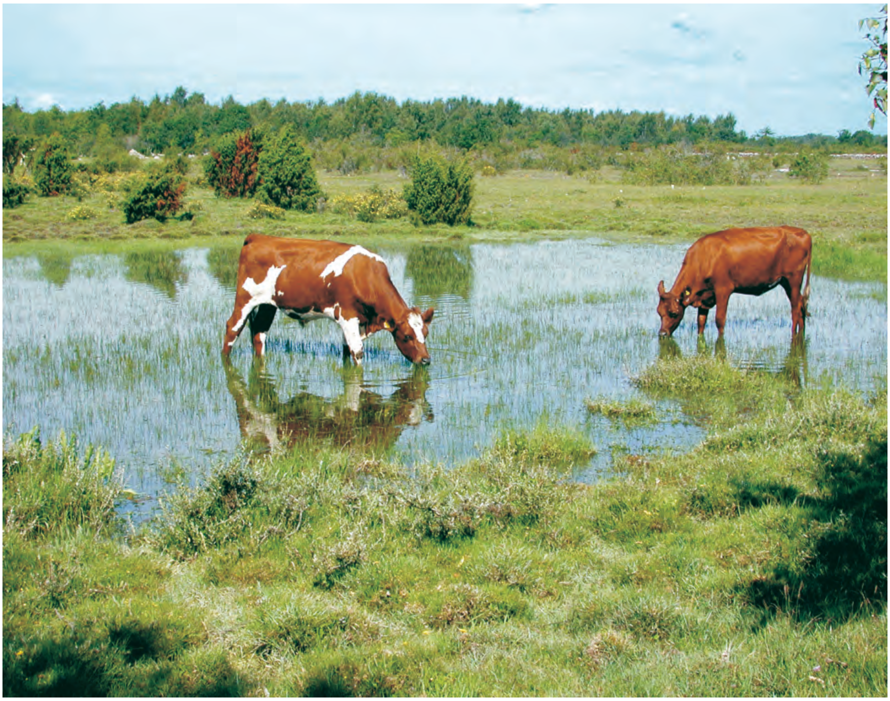

Fig. 9.6. 'Underwater grazing' by cattle: the connection to a traditional resting place and the entrance near the village to the 6 km² pasture is stronger than the drive towards 'normal' nutritional uptake. Sweden: Island of Oeland in midsummer (photo: H. Plachter)

ration for the 'preferred locations'. Under conditions which can easily be ascertained, such as on Oeland, set stocking pastures of several square kilometers are obviously no problem (Sect. 6.3). The upper size limit is always dependent on how 'management-extensive' one is prepared to be with the livestock. For 'semi-wild' keeping, as repeatedly recommended in the literature (if need be, as all-year-round grazing), set stocking pastures of over 10 km² are certainly a proposition under the right conditions.

Two further decisive livestock effects on large pastures which have hitherto hardly been considered were made clear in the investigations presented here: the dynamically changing habitat pattern over the year on the pasture and with that, the associated availability of 'temporary' habitats or resources for wild species (Sect. 6.2). Mowed grassland (meadow) is often accorded a higher nature conservation value than livestock grazing, whereby the latter is often implicitly understood to mean modern grazing systems (rotational grazing). Even for large-scale pastures this may be absolutely true in many cases up to the first cut. Meadow cutting is however a decidedly 'hard', and because of the so-called nature conservation agreements, increasingly synchronized intervention in the habitat quality of the occurring species, particularly the animal species (see Sect. 7.1). From one hour to the next, essential environmental qualities of a whole area such as flower occurrence, protection, a specific micro-climate or the vertical spatial structure of the vegetation is completely lost.

With this in mind, different variants such as strip mowing or unmowed buffer strips have been recommended in the professional literature, which in total have very little connection with the reality. The same is true for the current situation with the usual system of rotational grazing: the changes to the habitat determined by land use take place more slowly than over hours or the course of several days. However, the results are comparable: a uniformly mowed/grazed area without vertical spatial structure, without flowers, without woody vegetation and with very little structural diversity.

The pattern of use is quite different on large-scale set stocking pastures or in herded systems. Assuming a corresponding livestock density, a comparable amount of vegetation biomass is taken over the year, not simultaneously from the whole area or in several set intervals (mowing, stocking interval on rotational pastures) but in a continuous fashion. This is of no significance for the substance and energy balance but has considerable import for the habitat quality of wild-living animals and plants. Determined through behavior, the interventions of livestock have a mosaic characteristic and are 'stochastic' from the viewpoint of wild species. The consequences are that less mobile lifeform types such as spiders in the herbaceous layer are always able to withdraw to neighboring, 'undamaged' habitats. Mobile species such as nectar feeders are able to use existing resources in other places until those lost through livestock impacts can regenerate. Other species (such as dung or carrion residents; Sect. 5.2) find a spatial-temporal resource availability in such 'secondary habitats' which largely corresponds to their natural habitat requirements. Over the whole of the area, large-scale livestock grazing represents a highly dynamic, spatial-temporal resource availability although it is one which is evenly balanced; the systems used in meadows and rotational grazing, on the other hand, often mean that wild species are abruptly robbed of essential resources within their range of access.

9.4
Grazing and Other Life Requirements

Independently of all other life manifestations, the uptake of nutrition by livestock (often understood as 'grazing') has of course significant effects on the farmed ecosystems. It has long been known that these effects differ significantly between the different livestock species. However, investigations up to now have focused mainly on nutritional preferences (e.g., preferred plant species, tree browsing) and have hardly considered species-specific types of behavior (see e.g., Bokdam and Gleichman 2000).

On comparable set stocking pastures (see Sect. 6.3), it appears that cattle and sheep have a fundamentally different food search behavior. Sheep search suitable locations individually or in small groups where they select preferred food plants on small areas (see also behavior of wild sheep). For cattle on the other hand, the social 'herd drive' is dominant against individual preferences. Although the herd my split up during feeding into several sub-groups, the search for food within these is more or less linear and often done along a broad front. Cattle and sheep therefore have fundamentally different 'patterns of interference'.

With herded keeping, the patterns of behavior become more similar. The shepherd has the task of keeping the herd together. The natural behavior pattern of the sheep is therefore more strongly modified than that of the cattle. An indicator of this is the fact that herdsmen regularly need the help of dogs in order to control the flock, while cattle herds can be easily managed by one or two people.

Cattle clearly have a much greater impact on woody vegetation on large-scale set stocking pastures than was previously assumed (see Sect. 5.3 and 5.4). For the nutritional balance of the cattle, these manifestations certainly have no great significance, in contrast to sheep and above all to goats. However, because of very different behavior patterns and preferences, they can greatly influence the development of the vegetation on an area of pasture. This is based on three varying requirements: *(a)* curiosity, the 'drive to play' and grooming behavior (e.g., cleaning the body surface), *(b)* an inherent endeavor to search for preferred ecotones such as woodland edges, hedges and other linear boundaries, *(c)* the endeavor to find shadowed locations during high day-time temperatures, from where a comprehensive overview of the surroundings is possible (enemy detection).

Beyond all nutritional requirements and therefore outside of the usual mass and energy balancing in agriculture, this behavior has significant impacts on the development of woody vegetation on a pasture. Each woodland edge is a structural boundary line and is therefore perhaps more intensively grazed than the rest of the area, with the consequence that the forms of trees and bushes is largely determined by the cattle. Even with moderate grazing pressure, the establishment of further woody growths is more strongly affected close to existing growths by the grazing of young shoots than on other parts of the pasture. Isolated 'tree islands' have been described in many natural ecosystems dominated by herbivores. But even domestic herbivores can create such patterns if they consistently focus their feeding on boundaries between grassland and woody growths. It has long been known how efficient this type of nutrition selection can be, as in the case of woodland herbivores (roe deer, red deer). The biomass (in mass per area), however, usually lies a great deal below that of livestock on agricultural pastureland.

Behavior patterns justify a further important function of grazing animals: the distribution of nutrients over the ecosystem. Cattle (there is no current robust data on other livestock) observe a strict separation between feeding and resting areas on large-scale pastures. Resting areas are limited to areas with either a good water supply or good protection against potential enemies (light woodland edges with good visibility) (Sect. 6.3). After rest breaks, defecation and urination occur here. If these manifestations are carried out consistently on a particular area, then it is clear that this must lead to a gradual redistribution of nutrients around the ecosystem (Sect. 6.7).

9.5

Possibilities and Limitations for Livestock Grazing As a Contribution to Nature Conservation Management

In Central Europe, grassland is mainly found on locations capable of supporting woodland. At the end of regular zoo-anthropogenic interventions, succession leads fairly quickly to vegetation types dominated by woody growth. Not infrequently, species-poor intermediate stages arise in which one or a few tree species dominate (e.g., blackthorn, spruce through seed spread from neighboring woods; see Beinlich et al. 1995).

The key question for the suitability of livestock as an instrument of nature conservation management concerns the extent to which it is capable of preventing succession or modifying it in a direction acceptable to nature conservation objectives. The opinions in literature differ greatly and are more often colored by wishful thinking than by robust scientific data. It is not disputed that the favorable conditions for growth of woody vegetation and also for certain dominant grass species are so favorable on many types of soil that relatively strong interventions are required to bring about sustained suppression of these. It is also not disputed that the extent of the livestock impact is dependent on the stocking density (as an average value over the year). Although one may assume a highly differentiated spatial-temporal behavior, as could be shown for large-scale grazing, the relationships are by no means linear.

Situations have been described in which over the short term, livestock are actually capable of effectively controlling woody vegetation. This, however, does not mean that they would also be able to do this over longer periods. There is an uncertain balance between growth/spread of woody vegetation and the effects of livestock. If these effects are too weak over a short period, this could result in a 'tree explosion' such as is often observed with blackthorn shrubs.

The findings presented here are also unable to provide a clear answer to the question about the management efficiency of livestock alone. It should be noted that neither in historical times nor today were the interventions on pastures confined to livestock alone. In historical periods, there were basically three different intervention complexes which operated in parallel: the livestock itself, pasture management and secondary uses (Table 9.1). The latter has long since largely disappeared. Historically, trees and bushes on pastureland were seen as valuable resources (fuel, poles, braided materials etc.) which were used intensively. Even up to the nineteenth century on the

Table 9.1. Typical influences of the three equal-ranking 'stakeholders' on a 'historical' livestock pasture: livestock, pasture management and 'secondary uses'

Livestock	Pasture management	Secondary uses
Grazing	Suppression and removal of trees and bushes	Taking of wood for fuel
Browsing woody vegetation	Suppression of so-called 'pasture weeds'	Taking of (dwarf-) shrubs for other uses (brooms, litter etc.)
Trampling 'damage' to vegetation and soil	Removal of stones and accumulation to stone heaps and walls	Sod cutting of top-soil
Pasture-internal nutrient transfer	Water supply systems and integration of small stream	Collection of dung for fertilizer
Small-scale spreading of diasporas	Planting of shade trees	Frequent change to meadow and/or arable
	Creation of hedge lines for pasture boundaries	
	Sowing of 'tasty' grasses	
	Rolling	

island of Oeland, *Potentilla fruticosa* bushes growing on the Alvar were the basis of an extensive brush industry. Today, the species has spread in dominant growths over large areas which are now lost as pastureland. Mechanical control, for example, shredding, mulching) was required. Such secondary uses could be sufficiently strong on their own to control or stop the natural course of succession.

In many cases, historical grazing forms were much more variable over time than is recognized today. The general model of 'permanent grazing' which is often recommended nowadays has no historical parallel. Many areas were used for only a limited time as pasture and were used differently in the intervening periods, with the result that there were occasionally large interventions in tree and bush growths, before or during the change of use. Coppices were often used as arable fields (leaving the root stubs in the ground) followed by livestock pastures after the wood had been harvested. The coppice would still be able to regenerate. Grass-crop alternating systems were widely used and have been partially taken up again today in West Ukraine.

The temporal continuity of individual pastures and/or their structures was as a consequence frequently to a much lesser extent than is the case today. If the species abundance was however, high (as we must largely assume), this can best be explained by the spatial continuity of whole complexes of pastureland which allowed a recolonization of 'new' grassland areas in the close neighborhood. With every change of use from pasture to field, there was a constant need to remove woody vegetation.

The second impact complex, pasture management, must be classified as at least equally effective. Even up to the 1950s, pasture management required a considerable amount of the allotted time for livestock farming on common grazings in the South Black Forest (c.f. Sect. 6.6). The removal of woody vegetation (see shepherd's staff with digging shovel) certainly played an important role. However, pasture management in historical times was in no way confined to this alone. Particularly on very poor soils, extensive systems of walls bear witness to the efforts of farmers to maximize the natural plant growth. Further measures which were part of pasture management included the planting of trees to provide shade and the construction or optimization of watering places.

The stocking levels were very different on the areas which were investigated. They ranged from less than 0.1 LSU on Oeland to nearly 2 LSU on set stocking pastures in the Rhoen. In all cases, the stocking levels were adapted closely to the productivity and ranged in the upper region of the 'carrying capacity' of the respective pastures. On Oeland, the soil is decidedly shallow and in places not present at all, and in the Rhoen, it is almost good enough for arable farming. In all cases, the plant phytomass was exactly sufficient to feed the grazing animals. Because of dry weather in Oeland in 2002 and Germany in 2003, there were feedstuff shortages as early as the middle of the year.

Even under such conditions, however, it seems that cattle alone are in no way capable of effectively controlling tree and bush encroachment over the long term. The pastures on Oeland are regularly cleared of bushes (today as a nature conservation measure), mainly of juniper but also *Potentilla fruticosa*. The set stocking pastures of the Thuringian Rhoen are in part post-grazed with sheep and post-mowed in autumn, or even mulched. However, it is doubtful that the (additional) operation of other livestock (sheep, goats) could completely prevent natural vegetation succession over the long term. With very high stocking densities and in conditions unfavorable for bush development (summer dry periods, poor soils), this is conceivable. If at the same time, the desirable nature conservation spatial-temporal pattern of effects is aimed at, then this must result in some areas of overuse and clearly weak influences in other areas. However, these are starting points for the progressive development of woody vegetation which at a later stage would be too advance to be controlled by livestock.

Even if livestock alone are not capable of preventing all tree and bush encroachment or holding specific development stages at a stable level, the converse proposition is not valid that they are unsuitable as a management instrument for nature conservation, or 'less helpful'. Modern ideas about 'sustainability' require not only a rational compromise between social, economic and ecological objectives. They also require an intelligent way of dealing with control and management mechanisms. Without doubt, livestock grazing can be relatively favorably assessed because it comes close to natural 'disturbances' in ecosystems which have existed for millions of years, in any case closer than 'disturbances' through machinery or work teams. Regulating mechanisms in ecosystems do not often rest on one-sided influences of a single 'stakeholder' but much more frequently on feedback interactions involving several 'partners'. Herbivorous animals are then not just 'automatic biomass harvesters' similar to grass mowers, but are individuals which are highly sensitive to changes in the condition of their resources and react with changes of behavior or spontaneous adaptations. One can attempt to replace this with differentiated 'stewardship plans' but it is more sensible to trust in the evolutionary adaptation of the particular grazing animals.

Additional controlling interventions do not contradict this. Whether or not grazing animals have decisively controlled the vegetation development of the 'primal landscape' (which has not existed in Central Europe in the post-Ice Age period), there are however, other 'severe' environmental disturbances which we do not want to accept today for understandable reasons, at least in cultural landscapes: forest fires, wind damage, pest infestations, flooding, major climate changes. These less frequent 'severe' environmental disturbances must be replaced today in settled cultural landscapes as a rule with more frequent 'zoo-anthropogenic disturbances' (e.g., pasture management).

Consequently, livestock grazing alone cannot fully replace 'natural ecosystem management' (with the exception of so-called wilderness areas in which however the planned preservation of non-wooded habitats cannot be the objective). But compared to 'traditional' management strategies, livestock grazing can reduce costs and be closer to natural processes in its spatial-temporal operation.

High quantitative and qualitative requirements for labor, high material expenses and unfavorable product prices mean that beef and mutton production in the form of traditional suckler cow or sheep flock farming show high deficits in full cost calculations. To a large extent, the costs are linked to the livestock in that the smaller the livestock level is, the lower the deficits per unit of land. Because of this, the deficits on areas with low levels of vegetation growth such as former military training sites are much lower than for regular agricultural procedures, despite the lower livestock performances. Also in the case of model trials with semi-open grazing systems using Heck cattle and other 'semi-livestock animals', they have proved to be only moderately in deficit. Admittedly, these costing results need to be stabilized with future experiences in this area (see Sect. 8.1).

Grazing systems with heifer breeding for milk production are an exception. As long as qualitatively good heifers can achieve good prices, landscape management is an extremely economical operation. The recognition of this has lead to agri-political demands to preserve dairy farming in grassland locations, particularly in the low mountain ranges of Central Europe. This should be supported although the grassland serving as the feedstuff supply for the dairy cows only has a low nature conservation value and these intensive farming forms appear on the face of it to be the opposite of what this book is about.

The coupling with the breeding of young cattle, however, provides not only leeway for grazing forms acceptable to nature conservation, it is also welcome because of the tightly closed operational cycle of the farm, the short transport routes and not least because of the images of the product and its connection to a region. Added to this is the possibility of coupling traditional cooperative grazing systems with heifers and perhaps bulls, which are still around in certain regions. Not only does this open up opportunities for large-scale and heterogeneous grassland use, there are also possibilities for further cost reductions. As could be shown in Sect. 8.3, such structures and savings potentials in regions characterized by large farms such as in the new states of the former East Germany can be achieved even within individual enterprises.

For decades, the agri-political subsidy regime of the European Union has determined not only the organization of production but also the acts and omissions of agricultural enterprises in fine detail. This point deserves particular attention in a book about large-scale grazing. The authors of Sect. 8.2 were daring enough to imagine the effects that glaringly different hypothetical 'agricultural policies' on land use in a specific community in the Rhoen would have. Not unexpectedly, for example, the scenario 'abolition of all agricultural subsidies' leads to a major reduction in farmed areas with all the accompanying problems for the agricultural budget. The other scenario results are equally informative and are explored also with interviews of the local farm managers (see Sect. 7.6).

The future prospects of a land use favorable to nature conservation and not least to the visual quality of a landscape (and therefore to the recreational suitability) is not decided alone by the extent to which agricultural subsidies flow into it, but more so to its structure. Of course, high subsidy payments per unit area are welcome to the local farmers and may support the financial analyses of large-scale grazing procedures carried out in this book. However, they can discourage the farms from these systems by providing incentive to implement other land use or management forms which are of less benefit to nature conservation but promise greater profit. Many observers fear that the decoupling of subsidy from individual grazing animals, in place since 2005, would mean that grassland enterprises in the Central European low mountain ranges would give up their livestock and turn to a more economic minimal land management with mulching.

The following four business economic and subsidy policy considerations are relevant with respect to the achievability of large-scale grazing:

- Cost reductions through low-maintenance keeping procedures, inter-farm organization, creation of common cattle herds etc. The potentials arising here are in no way 'exhausted' (see Sect. 8.3). However, the mobilization of all possibilities of this type are not sufficient alone to achieve a full cost coverage and discourage undesirable environmental alternatives.
- Increased production of premium goods. Regional successes cannot be ignored but it has been repeatedly confirmed for some time that this strategy is only available

to a minority of producers. Apart from this, the calculations in Sect. 8.2 show that the attainment of full cost coverage through this alone is doubtful.

- Financial business support, especially with investment. Experience shows that sheep farming in line with nature conservation often only exists when fixed costs are covered by a third party. The classical example is the construction of a stall by municipalities, development associations etc. The resources of the investment funding are not sufficiently applied to nature conservation goals. Numerous dairy establishments keep their heifers in stalls or on intensive pastures close to the farm. Heifer breeding in line with nature conservation means additional costs in the form of separate feedstuff chains and storage capacity, which an enterprise would normally avoid but would accept if subsidy was available.
- Targeted reward for ecological performance. The scenario calculations in Sect. 8.2 confirm once more that this instrument is most suitable in encouraging land users to become contributors to nature conservation efforts. Of course, the level of the reward must be appropriate. However, through the reward, not just money is given out but in addition, specific performances are demanded and the payment only takes place on 'delivery'. As was briefly described in Sect. 8.2 (and complemented with references to detailed literature sources), success-oriented reward is advisable for variants.

It is not only in regions with large-scale grazing but overall in rural areas that in the future, the earnings from land use should consist of a combination of appropriate product prices with success-oriented reward for landscape management.

Agricultural production capability in peripheral areas is more strongly dependent today on public subsidy than in favored areas. The current EU agricultural policy is based on support of the currently usual (mass oriented) production forms, and not seldom under the basic conditions of old paradigms. Not just the extent but also the type of support necessarily has a decisive influence on the implemented land use forms at farm level. It is understandable that farmers who actively contribute to nature conservation and landscape stewardship which go beyond the social tie to the property (see 'good agricultural practice') should also be rewarded for this. One possibility would be to increase the corresponding level of public support.

Basically, there are four different ways to achieve this:

1. focusing the system of public subsidy (especially from the EU) on corresponding nature conservation performances
2. providing support for important farm resources, including through investments, in connection with livestock grazing
3. increased production of premium goods from livestock farming
4. reduction of costs through low-maintenance keeping forms (all-year outdoor keeping) and inter-farm organization (common herds on inter-connected lands)

It should be possible in many cases to realize a combination of all four ways. Then large-scale livestock grazing could actually become an economically favorable, and with reference to the goals of sustainability, particularly advantageous strategy which would bring together economic, social and ecological benefits.

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